# TUFTS COLLEGE STUDIES

(Scientific Series)

VOLUME II

Published by the Charles Hyde Olmstead Fund

TUFTS COLLEGE, MASS.

1905-1909

2385

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### NUMBER I. DECEMBER, 1905.



### NUMBER II. MAY, 1906.



### NUMBER III. JULY, 1909.

# THE GREEN ALGAE OF NORTH AMERICA

THE TUFTS COLLEGE PRESS

TUFTS COLLEGE STUDIES, Vol. II, No. 3.

# THE GREEN ALGAE OF NORTH AMERICA.*

By Frank S. Collins.

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*Contributions from the Harpswell Laboratory of Tufts College, No. 32.

## INTRODUCTION.

In the following pages it is intended to give an account of the green algae of North America, with as much detail as will enable the student to recognize the species, and have some idea of their development and affinities. North America in this sense includes everything from the Arctic Ocean to the Isthmus of Panama, including the West India Islands. In the green algae are included not only the Chlorophyceae, in the narrower sense, but also the small class of the Heterokontae. On the other hand two families are omitted, the Desmidiaceae and the Characeae; the former, though closely related to the other Conjugales, has generally been taken as a separate study, for special students; to include it with as much detail as the other algae would practically double the size of this work; moreover the American desmids are not well enough known at present. The Characeae, on the other hand, are widely separated from all other algae, representing the last term in a long line of development, diverging from the main line at some remote time, so remote that it is hard to guess at what point it started.

Under each species will be found a concise description, with a record of the localities in which it has been found; if in the United States, the State is given, but seldom any more exact location. Reference is given to the original publication of the binomial, also to some good plate or figure; where there has been distributed in some set of exsiccatae a specimen that can be identified with the species in question, reference is made to this; by preference use is made of the Phycotheca Boreali-Americana of Collins, Holden & Setchell, as being at once the fullest for American algae, and the most accessible for American students. References are also given to three standard works: — Harvey, 1852, Farlow, 1881, and Wolle, 1887. Where the basis of treatment of any family or genus has been the monograph of any author, reference is made to such monograph under each species. In special cases other references have seemed desirable, and have been made.

In the plates there will be found at least one figure for each genus; in most cases these are taken from standard works, often from the original description of the species represented. Where a choice had to be made of the species to be represented, in some cases a type was selected other than the one most familiar to American students in the usual text books.

It has not seemed necessary to furnish any glossary of botanical terms used, but such terms as are special to the forms here described, and which would not be found in ordinary botanical works, have been included in the index, with a reference to the page in which they are used and explained.

In the present imperfect state of our knowledge of the green algae, it would be unsafe to make deductions as to distribution from the records of localities here given, that is, as to their absence from regions not noted. In fresh water algae especially the greater part of our territory is "terra incognita." Beginning at the north, we have Greenland, with a limited flora of fresh water algae, but probably as completely known, thanks to the Danish botanists, as that of any other region of the same size within our scope. New York and New England have been considerably explored, and there are some few records from West India Islands. The fresh water algae of California and

Oregon, near the coast, have been collected to a considerable extent within the past few years; but for the rest of the United States there is only the record of a few species, here and there, at isolated stations. Lists have indeed been published, at various times, of local floras, but when the attempt has been made to see the material on which these lists were based, it has usually been found impossible; in the few cases where the material was accessible, so many determinations were found to require correction as to make it out of the question to accept the determinations of lists whose material could not now be examined. For such great regions as Canada and Mexico practically no records exist. As regards marine algae the case is not quite so bad. They follow the seashore, and it is easier to become familiar with the narrow strip that represents their distribution, than with the great enclosed area through which the fresh water species are to be found. The stretches of shore of which we are still ignorant are not disgracefully long. But while in fresh water collections the green algae constitute the greater part, and include the most conspicuous forms, the collector at the shore, if not a specialist, is likely to bring away the showy brown and red algae, to the neglect of the less notable green plants. The marine flora of Greenland is as well known as that of any region of the size; that of the New England coast has been studied for many years, but from New Jersey to Florida, published records are quite insignificant. Some recent observations at Beaufort, North Carolina, at the laboratory of the U. S. Bureau of Fisheries, which the authorities have kindly allowed to be here used, to some extent supply this deficiency; the flora of Key West is probably as well known as any tropical or subtropical flora; lists of considerable completeness have been published for a number of the West India Islands. But beginning with the west coast of Florida, all the way round the Gulf of Mexico to the isthmus, we have practically no records; the same is the case on the Pacific coast from the isthmus to California; from the Mexico-California boundary north to the Arctic Ocean observations have pretty well covered the coast line, and it is not likely that any special flora has escaped our notice. This does not mean that we are fully acquainted with any region; even on the New England coast, which has been studied so long, species new to the region are continually turning up.

Not only in comparing different regions, but in comparing different families and genera, the treatment must be unequal. For the family of the Oedogoniaceae, for instance, we have Hirn's admirable monograph, based on an ample supply of material, American as well as foreign; from this a very satisfactory account of this family can here be given, but with the proviso that species described by Hirn from extra-American localities will probably some time be found here. Of the genus Chlamydomonas Wille has published a thorough revision, but with no reference to American material or localities; little attention has been given to the genus here; only fresh material can be used for study, so that practically the genus will remain unrepresented. A case different from both these is presented by the genus Cladophora; probably more species have been described in this genus than in any other genus of algae, except possibly some of the minute diatoms and desmids. Cladophoras abound everywhere, in fresh and salt water; herbarium specimens are practically as good for purposes of determination as the living plants; and yet this genus presents more difficulties than any other treated in this work. Species have been described recklessly, from imperfect material, often with little or no consideration of what had before been described; the plants vary much in response to environment, and the individual plant may vary much at different stages of growth, but except in a very few instances we have no investigations to show just what forms belong in the same life cycle. These three instances show the inequality that exists, and must long exist, in our knowledge of the different types about to be considered.

Under each genus will be found a key, for convenience in identifying plants under consideration. These keys are based as far as possible on the more obvious characters, which are not necessarily the more important systematically, but the systematic characters will be found in the appropriate place under each species. The characters used will apply only to the species here given, and would mislead if used for species of other regions. Each distinction in the key being founded on a single character, it may sometimes happen that one will be led in this way to a specific description differing in other characters from the plant in hand; in such case it may be that it is a species new to this region, and reference should be had to more general works.

At the end of the descriptive part of the work will be found a list of the works referred to, arranged alphabetically by authors, the date being given after the author's name; in the text the reference will be by name and date only, full particulars of title, etc., being given in the list. This does not attempt to be a full catalogue of works on American algae; for an account of these, published previously to 1889, see De Toni, 1889; for works with special reference to American algae, see Tilden, 1895; later than these dates the bibliographical notes in Just's Botanischer Jahresbericht, Nuova Notarisia, Botanische Centralblatt and Hedwigia will be useful, as also the Index to American Botanical Literature in the Bulletin of the Torrey Botanical Club. The labels of the several numbers in the Phycotheca Boreali-Americana often have a pretty full bibliography of the species.

In nomenclature, the rules of the Vienna Congress have been used as a basis; but as these rules were adopted completely only as to the higher plants, the question of a starting point for the nomenclature of algae being referred to a future congress, it has seemed unwise at present unnecessarily to disturb well established names. As regards classification, the general arrangement is that of Oltmanns, 1904, but with some variations in detail.

Anything of the character of the present work, whatever name appears as that of its author, represents, if it is of any value, the work of many individuals. Limitations of space prevent giving exact localities and collectors' names under the several species, and so many have aided the writer by contributions of material from localities that he could not himself visit, that a general acknowledgement of their assistance must suffice. But a few names must be mentioned. To Prof. W. G.

Farlow of Harvard University the writer owes his first encouragement in the study of algae; for this, for assistance and advice through many years, and for the opportunity to consult his unrivalled library and collections, the most hearty acknowledgement is offered. With Prof. W. A. Setchell of the University of California the writer has been associated for many years in collecting and studying, and much of value in the present work is due to his contributions and suggestions. That so good a representation can be given of the green algae, marine and fresh water, of the Pacific coast States, is chiefly due to Dr. N. L. Gardner of Los Angeles, California, an acute observer and indefatigable collector. To many European botanists thanks are due for information as to types and for materials for comparison; most of all to Dr. Edouard Bornet of Paris, the value of whose advice and assistance is equalled only by the unfailing promptness and courtesy with which they were given. To Prof. J. S. Kingsley and Prof. F. D. Lambert of Tufts College, the writer is indebted for opportunities for collecting and study during the seasons he has been at the Laboratory at Harpswell, Maine, and for many facilities given and kindnesses shown; the plates which it is hoped will add materially to the value of the paper are also their work.

No one can know as well as the writer how incomplete the work is, and how likely it is that errors will be detected; but no pains have been spared to make it as complete and accurate as possible. There can be no question that a work on the subject has been needed; if this will stimulate study and increase knowledge, so that a better work can soon take its place, it will have justified its existence.

Before algae are studied they must be collected, and a few hints in this regard may be of use. Only the green algae will be taken into account in this respect, but as the different types of green algae require different treatment, practically every contingency as to other types of algae will be provided for. In temperate regions the marine green algae are largely littoral plants, that is, inhabiting the zone between high and low water marks; in quiet bays and pools they may form dense floating masses, but very few have to be sought below low water mark. In the extreme north the temperature and the shore ice permit practically nothing to exist uncovered by water, and all algae must be obtained by dredging. The same result is reached, in part, in the subtropical waters of the West India region, but by different causes; tides are slight and irregular, and exposure for any length of time to the intense sunshine would be fatal to delicate forms; here also one must look below the surface.

In many genera of marine Chlorophyceae the individual plants are large enough to be easily seen (*Ulva*, *Cladophora*, *Udotea*, etc.) but for the greater part only the mass, not the individual, can be distinguished (*Rhizoclonium*, *Codiolum*, etc.) while others appear as a thin film on wood or stone (*Pseudendoclonium*, *Pilinia*, etc.) or as a coloration of the shell in which they are imbedded (*Gomontia*). Then there are endophytic forms (*Bolbocoleon*, *Chlorochytrium*) not at all manifest, and only to be found by dissection of the host plant. These conditions being so varied, the only safe course for a student is to collect everything of a green color that he does not recognize. Few of the marine green algae are specially sensitive; in most cases they can be kept a reasonable time immersed in salt water, or packed in cloths moistened with salt water, if not subjected to higher temperature than that of the water in which they grew; but if plants or portions of plants to be studied must be kept for several days, it is better to keep them in salt water to which enough ordinary formalin (formaldehyde) has been added to make a three per cent. solution. Of course no action of the living plant can then be observed, but the structure is maintained practically intact for months, as far as would be needed for anything described in this work. For permanent preservation of these algae, nothing is better than the herbarium form. In many genera whatever characters are needed for systematic purposes can be obtained from herbarium specimens, and in those cases where characters cannot be made out as satisfactorily in the dried specimens as in fluid preparations, at any rate whatever is available continues so for an indefinite time, while it is only too common to find a fluid preparation worthless. As regards microscopic slides, they can be prepared so as to show beautifully some particular structure, but here too, permanence is far from assured. Moreover the slide shows just the one thing in the one position; there is no changing or moving it.

There are some genera of tropical algae that can be prepared for the herbarium practically the same as flowering plants (calcareous algae like *Halimeda*, and coarse non-calcareous forms like *Avrainvillea*) by pressing between driers and then strapping or gluing to herbarium sheets. Of green algae of temperate regions *Ulva* and some species of *Cladophora* and *Chaetomorpha* are all that can be treated in this way; most species that are of sufficient size for the individual fronds to be shown (*Bryopsis*, most *Cladophoras*) should be mounted on paper, and the paper attached to the herbarium sheet; the plant should be allowed to spread out in natural form in a shallow dish or pan of salt water, the paper placed under it and carefully raised, until it, with the undisturbed specimen, is lifted out. The papers are then placed on driers, specimens up, a piece of cotton cloth the size of a drier laid over all; then another drier, specimens, cloth, etc. After this the process is much as for flowering plants; greater or less pressure according to the character of the specimens; changes of driers as fast as they become moist, but no change of cloths; these not to be removed until specimens are thoroughly dry and ready for the herbarium. The heaviest driers should be used, as the amount of moisture to be taken up is so much more than in land plants. Frequent change of driers, and having them thoroughly dry when used, will add much to the value of the specimens. Nearly all algae prepared in this way will adhere to the paper.

Those forms in which the individual plants are minute (*Codiolum*, *Prasinocladus*) of course cannot be treated in this way; a small portion of the thin pasty mass can be spread with a knife on a piece of paper, and then dried without cover or pressure. It is sometimes better to use mica instead of paper for very minute forms; they are then ready, when moistened, for microscopic examination, without removing from paper to slide. Where mica is used and a large number of specimens are to be prepared, it is often convenient to add more water and drop from a pipette on the mica.

The three methods just given practically answer all requirements for marine algae. There are no fresh water algae that will require the first method; a few (*Cladophora*, *Oedogonium*) are best treated by the second, but the greater part require the third.

In collecting fresh water algae it will be found to be the rare exception that a species can be recognized in the field; one must sample everywhere; at first the abundance of new forms will be so great that a few such samplings will give materials for hours of study; later, as one is more familiar with the flora of a region, the proportion of novelties becomes smaller, and after a while one is satisfied if only nine out of ten collectings are thrown away after a hasty examination. On the other hand, one will often find in a small bottle of material enough forms for days of study. In such families as the Zygnemaceae and Oedogoniaceae only fruiting specimens are accurately determinable; in all but a few of the larger forms the microscope is needed to decide as to the presence or absence of fruit. One must continue to collect, though the proportion of prizes will grow steadily less. As a partial recompense, one often finds minute epiphytic algae attached to the larger sterile plants and minute plankton forms lying loose among them. These minute unattached forms are very interesting, and have been studied but little in this country. Wonderful collections can sometimes be made by drawing a fine net through the water, but a surprising variety can also be found entangled among *Utricularia* and other water plants, or adhering to the gelatinous coating on stems and leaves of *Pontederia*, *Brasenia*, etc. In the latter case the material can be scraped off; in the former it is better to squeeze the plants thoroughly, remoisten and again squeeze; this can be repeated many times before the supply of algae fails. If the liquid stands in a jar or bottle, in a few hours the algae will settle to the bottom; the liquid can be drawn or carefully poured off. If then formalin be added, enough to make the liquid a three per cent. solution, the material can be studied at leisure.

The effect of formalin is not permanent, and where permanence is needed, other preparation must be used. The technic for microscopic, histological and cytological work is now so elaborate and varied that no attempt can be made here to give any details. Perhaps the best reference for it is Chamberlain's Methods in Plant Histology.

One process specially useful in studying herbarium specimens of green algae appears not to be generally known or generally mentioned in the technical works, and it may be well to note it here. When a herbarium specimen of a green alga is moistened and submitted to microscopic examination, it is often found that the shape of the cell as well as of the chromatophore has been lost in the shrinking in drying, and not recovered by moistening. If then the bit of moistened alga is laid on the slide, in a drop or two of concentrated lactic acid, then warmed until bubbles appear in the fluid, it will often be found on putting on the cover glass and examining the specimen, that the structure of the original has been much restored.

The instructions just given for collecting and preparing algae are more in the way of hints and suggestions than of full directions. One learns by practice, and not much any other way; the "knack," the little contrivances, will soon be acquired. Those who prefer fuller directions will find them in Harvey, 1852, Farlow, 1881, Setchell, 1899, Collins, 1899, West, 1904.

Many kinds of algae can be kept alive for a long time, with proper care as to fresh water, light etc.; development can be studied, and often new and unexpected forms may appear; by adding certain substances to the water, reproductive organs of different kinds can often be developed; but this, as well as the matter of pure cultures, opens up too large a field for the present work.

As regards classification, a brief notice should be given. Any statement, even approximately full, of the supposed phylogeny and relations of the green algae would require more space than can be given in a work of this character. The most plausible theory now is that the green algae are descended from the Flagellates, a class of organisms that has been claimed (and declined) both by botanists and zoologists. The Flagellates are actively moving unicellular organisms, and in nearly all the green algae this ancestral form reappears as the zoospore, the permanent condition in the ancestor being only the transient condition in the descendant. Two distinct lines seem to be traceable, from two types of Flagellates; one producing the small class of Heterokontae, the other the remaining green algae. Some authors have further divided the latter, and as the Heterokontae derive their name from the unequal cilia of the motile stage, the name Isokontae has been proposed for algae whose motile spores have two equal cilia; the Akontae for those with no motile ciliate stage, and the Stephanokontae for those with many cilia arranged in a circle. But this desire for symmetry seems to come under the head of "trop de zèle"; there is fully as much reason to suppose that the Conjugales (Akontae) have lost the motile stage possessed by their ancestors, and that some at least of the multiciliate organisms are modifications of the biciliate type. See Davis, 1908.

From the nature of the case, all the forms here to be described must be arranged in a linear series, but it is to be hoped that no one will suppose that their relative rank can be determined by their position in the series. The general arrangement is from the more simple to the more complex; Order A, the simpler, being followed by Order B, the more complex; and in each order family a, the simpler, is followed by family b, the more complex; but it is almost always the case that family z, the most complex of Order A, is considerably in advance of family a in Order B. A glance at one of the diagrams that have been made to show the probable filiation of the different types will give an idea of the complexity of the matter. Change is not necessarily progress; retrogression is often evident. The preservation of the individual or of the type may be secured by very many appliances or adaptations, thus forming diverging lines of development, some reaching a point where further progress in that line is impossible, others continuing, perhaps giving off lateral lines here and there. All schemes of showing these tendencies and results assume the former existence of intermediate forms, now extinct; and so imperfect is our knowl-knowledge of what remains, that it is evident that many schemes may yet be proposed before we have one satisfying all the requirements. No attempt will here be made to give any such schemes; those interested will find them in Bohlin, 1901 a; Blackman and Tansley, 1902; West, 1904; Oltmanns, 1905. The general statement of the classification used here is this: — One small class, the Heterokontae, including algae whose motile cells have cilia of unequal length; whose vegetative cells contain chromatophores colored yellowish with xanthophyll, without pyrenoid, and whose reserve materials are in the form of oil rather than starch. The other class, the Chlorophyceae, includes all algae with true chlorophyll-green chromatophores, starch reserves, pyrenoids usually present, and whose motile cells have cilia of equal length. The Heterokontae contain but one order, Confervales; the Chlorophyceae six; Volvocales with the motile stage more prominent than the non-motile; Conjugales, with no motile stage; and four others with reproduction by various sexual or non-sexual motile spores or by aplanospores, evidently a modification of the zoospores; in these orders there is so much variety in this respect, other characters often remaining unchanged, that a classification based on the reproductive bodies would seem highly artificial, a distinction based on other characters more natural. So we have the uninucleate Protococcales, the cells solitary or in loose colonies; the membranaceous or filamentous Ulotrichales, also with uninucleate cells; Siphonocladiales with multinucleate cells; and Siphonales with no distinction of cells, the many nuclei distributed all through the interior of the plant. In each of these orders there is great diversity of characters, both as to complexity of structure and as to reproductive characters; extremely simple vegetative growth being accompanied with very elaborate reproductive mechanism in *Oedogonium* and *Vaucheria*, for instance; remarkable variety of external form in the various species of *Caulerpa*, with no reproductive process whatever known. In many genera, even of conspicuous plants, we still have to write "reproduction not well known" or even "reproduction unknown." The division of the orders into families will appear as they are reached in the following pages, and requires no comment here.

## Class I. HETEROKONTAE.

Motile cells with two cilia of unequal length; chromatophore more or less distinctly yellow green; reserve material oil, not starch; no pyrenoids.

Under this name are included by Oltmanns and others, the family Chloromonadaceae of the Flagellates, with genera of algae supposed to be derived from it; in distinction from the great body of green algae, whose descent is from other forms of Flagellates; the name is based on the unequal length of the two cilia, one of the two being sometimes quite imperceptible; though the distinction may appear somewhat artificial, it seems to cover a distinct line of descent and development. Only one order of algae.

### Order CONFERVALES.

KEY TO THE FAMILIES OF CONFERVALES.

1. Terrestrial; cell vesicular, with branching underground prolongations. 2. BOTRYDIACEAE.
1. Chiefly aquatic; filamentous or unicellular, without branching prolongations. 2.
   2. Unicellular; cells free or connected by gelatinous strands; sexual reproduction by gametes. 3. CHLOROTHECIACEAE.
   2. Unicellular or filamentous; cell wall with little cellulose; sexual reproduction unknown. 1. CONFERVACEAE.

#### Family I. CONFERVACEAE.

Cells free or united in attached or free monosiphonous filaments; cell wall with little cellulose, mostly pectin; chromatophores usually many, disk-shaped, always without pyrenoid, cells containing more or less oily matter but no starch, one or more nuclei; asexual reproduction by zoospores with two cilia of unequal length, or by aplanospores which often seem to take the place of zoospores under certain conditions of environment; all plants of fresh water.

The Confervaceae, as here limited, include genera that have been placed at widely different points in the series of green algae, and their association here is by no means free from questions; some of them have been reported as having two cilia of equal length, some as having only one; but these reports may be due to imperfect observations. In most of the genera there is a peculiar stratified arrangement of the cell wall, by which the upper part fits over the lower, like the cover on a pill box; in *Conferva* this results, when the cell breaks open, in the formation of the so-called H sections, formed of the upper half of one cell and the lower half of the cell above it.

KEY TO THE GENERA OF CONFERVACEAE.

| | | |
|---|---|---|
| 1. | Cells elongate. | 2. |
| 1. | Cells globose or subglobose. | 3. |
| 2. | Cells united into filaments. | 4. CONFERVA. |
| 2. | Cells solitary or attached by their slender bases. | 2. OPHIOCYTIUM. |
| 3. | Cells united into gelatinous filaments. | 3. CHLOROBOTRYS. |
| 3. | Cells solitary, free. | 1. BOTRYDIOPSIS. |

1. BOTRYDIOPSIS Borzi, 1894, p. 199.

Frond unicellular, globose or subglobose, uninucleate, free; containing more or less numerous small chromatophores without pyrenoid. Asexual reproduction by numerous zoospores, showing amoeboid changes of form and having two unequal cilia.

The type species, *B. arhiza* Borzi, has not been found in this country, but two new species have been described, as below. Nothing is known of them other than the descriptions of Miss Snow, and their distinctness from the European species may be questioned.

B. ERIENSIS Snow, 1903, p. 384, Pl. III, fig. XIII, 1-7. Cells 18-21 $\mu$ diam.; chromatophores hexagonal when young, elongate when older: zoospores usually 16 or 32 in a cell, escaping through an opening in the cell wall, about $5 \times 3$ $\mu$, with red stigma, and only one cilium showing distinctly. Fig. 1. N. Y.

B. OLEACEA Snow, 1903, p. 385, Pl. III, fig. XII, 1-10. Similar to *B. eriensis*, but less regularly globose, not over 13 $\mu$ diam., chromatophores densely packed, a red globule near the center of the cell; zoospores $5\text{-}8 \times 3\text{-}5$ $\mu$. N. Y.

2. OPHIOCYTIUM Nägeli, 1849, p. 87.

Cells free or attached to water plants, multinucleate, cylindrical or claviform, one end frequently capitately swollen; straight, arched, curved in S-form or spirally; solitary or in umbellate or corymbose families; at each end rounded, truncate, or mucronate, or rounded at one end and with a stipe or spine at the other; chromatophores many, parietal, without pyrenoid; cells sometimes containing yellowish oil globules; asexual reproduction by aplanospores, or by biciliate, ovoid-oblong zoospores, formed few to many in a cell, escaping by the breaking off of the cap-like end of the cell; in some species germinating directly at the summit of the mother cell, in others entirely independently.

Not uncommon among other algae, especially the unattached forms; but seldom found in large quantity. The present treatment of this genus follows Lemmerman, 1899, including *Sciadium*, generally kept distinct on account of the new generation developing at the summit of the older cell; but as this same development is found in varieties of some species of *Ophiocytium*, in the older sense, the distinction cannot be kept up.

KEY TO THE SPECIES OF OPHIOCYTIUM.

| | |
|---|---|
| 1. Attached. | 2. |
| 1. Free. | 3. |
| 2. Cells 5-7 μ diam., stipe 10-14 μ long. | 6. *O. gracilipes.* |
| 2. Cells 3-5 μ diam., stipe 2-3.5 μ long. | 5. *O. arbuscula.* |
| 3. Bearing a stipe or spine. | 4. |
| 3. Both ends rounded or truncate. | 4. *O. parvulum.* |
| 4. Stipe with capitate end. | 1. *O. majus.* |
| 4. Stipe or spine acute. | 5. |
| 5. Spine at one end. | 2. *O. cochleare.* |
| 5. Spines at both ends. | 3. *O. capitatum.* |

1. O. MAJUS Nägeli, 1848, p. 89, Pl. IV. A, fig. 2; Lemmerman, 1899, p. 29; Phyk. Univ., No. 19, b. Cells solitary, 8-17 μ diam., spiral or curved in S-form; at one end with a straight or curved stipe with capitate end; cells often with hyaline or yellowish oil globules. Fig. 2. Mass. *Europe.*

2. O. COCHLEARE (Eichwald) A. Braun, 1855, p. 54; Wolle, 1887, p. 175, Pl. CLVIII, figs. 8-14; Lemmerman, 1899, p. 30, Pl. III, figs. 10-12; P. B.-A., No. 1424. Cells solitary, 5-8 μ diam., arched or spirally twisted, bearing at one end an acute spine 1-12 μ long. Me., Mass. *Europe.*

3. O. CAPITATUM Wolle, 1887, p. 176, Pl. CLVIII, figs. 3-7; Lemmerman, 1899, p. 31, Pl. IV, figs. 16-18. Cells solitary, 5-10 μ diam., arched, S-curved or spiral, with an acute spine 5-7 μ long at each usually swollen end. Mass., N. Y.

4. O. PARVULUM (Perty) A. Braun, 1855, p. 55; Wolle, 1877, p. 176; Lemmerman, 1899, p. 33, Pl. IV, figs. 31-33; Rabenhorst, Algen, Nos. 516, 1546. Cells solitary, 3-9 μ diam., straight, arched or spiral, rounded at each end. Greenland, Me., Mass., N. Y. *Europe.*

Var. CIRCINATUM (Wolle) Lemmerman, 1899, p. 34, figs. 15-18; *O. circinatum* Wolle, 1887, p. 176, Pl. CLVIII, figs.

15-18. Cells solitary, 10-13 μ diam., in a spiral of two to many turns, both ends rounded. Minn. *Europe.*

Larger than the type, and always in a spiral, usually of many turns.

5. O. ARBUSCULA (A. Br.) Rabenhorst, 1868, p. 68; Lemmerman, 1899, p. 28; *Sciadium arbuscula* A. Braun, 1855, p. 49, Pl. IV; Wolle, 1877, p. 174, Pl. CLVII, figs. 1-6; Wittr. and Nordst., Alg. Exsicc., Nos. 401, 1360. Cells always united in families, umbellate or corymbose, straight, 3-5 μ diam.; stipe slender, 2-3.5 μ long, connecting the lower end with the basal disk.

Mass. "Specimens from three or four states." Wolle. *Europe.*

6. O. GRACILIPES (A. Br.) Rabenhorst, 1868, p. 68; Lemmerman, 1899, p. 28; *Sciadium gracilipes* Wolle, 1887, p. 175, Pl. CLVII, figs. 7 and 8; Bohlin, 1897a, Pl. I, figs. 27-32, 35, 39, 40; Pl. II, figs. 59 and 60. Cells in a simple umbel, 5-7 μ diam., stipe 10-14 μ long, to the disk-like base. Minn. *Europe.**

3. CHLOROBOTRYS Bohlin, 1901, p. 34.

Cells globose, with several disk-shaped chromatophores without pyrenoid, with more or less oil; cells 2-16 united by a hyaline tegument; asexual reproduction by short cylindrical akinetes, with thickened membrane, formed from vegetative cells; also by cell division.

Only one species.

C. REGULARIS (West) Bohlin, 1901, p. 34, fig. 9; West, 1904, p. 254, fig. 119. Cells globose, 10-27 μ diam., united by a gelatinous coating into families up to 90 μ diam. including the coating, cells sometimes in contact; chromatophores 6-30 in a cell; asexual reproduction by division of a cell into 2-4 daughter cells, also by akinetes. Fig. 3. Common in various parts of Europe, and reported by West from the United States.

4. CONFERVA Linnaeus, 1737, p. 326.

Filaments at first attached by a special basal cell, later free; cells uninucleate, rarely with two nuclei; chromatophores disk-shaped, two to many in a cell, without pyrenoid, producing oil but not starch; cell wall thin, breaking up into H sections.

*O. CUSPIDATUM (Bailey) Rabenhorst, 1868, p. 68; Wolle, 1887, p. 176, Pl. CLVIII, figs. 1-2; *Closterium cuspidatum* Bailey, in Ralfs, 1848, p. 219, Pl. XXXV, fig. 11; *Reinschiella ? cuspidata* De Toni, 1889, p. 614. A problematical plant; it is doubtful if it belongs to any one of the genera in which it has been placed, and it certainly deserves investigation. The cells are crescent-shaped with rounded ends, like a broad *Closterium*, each end terminated by a stout spine. The cells measure 150×165 μ, the spines are 15 μ long.

Asexual reproduction by 2-ciliate zoospores without red stigma produced 1-4 in a cell; also by aplanospores.

Under the name *Conferva*, dating back to the time of Pliny, Linnaeus included the greater part of the filamentous algae; by the steady segregation of a century and a half, it has been reduced to a small group of fresh water algae, and is here taken in the extension given it by Lagerheim, 1889, p. 194. On account of the impossibility of determining what plant was the 'type,' in the taxonomical sense, of Linnaeus, Hazen proposes to drop the name *Conferva* entirely, substituting the *Tribonema* of Derbès and Solier, of 1856. This seems rather too heroic treatment, as all the plants included in Lagerheim's *Conferva* have long borne that name, would certainly have been included by Linnaeus under it, and cannot be placed in any other accepted genus.

KEY TO THE SPECIES OF CONFERVA.

| | | |
|---|---|---|
| 1. | Chromatophores 2-4, symmetrically disposed. | 2. *C. minor.* |
| 1. | Chromatophores numerous. | 2. |
| 2. | Filaments 3-6 $\mu$ diam. | 1. *C. bombycina* forma *tenuis.* |
| 2. | Filaments 6-11 $\mu$ diam. | 1. *C. bombycina.* |
| 2. | Filaments 11-16 $\mu$ diam. | 3. *C. utriculosa.* |

1. C. BOMBYCINA Agardh, 1817, p. 78; Wolle, 1887, p. 142, Pl. CXXI, figs. 8 and 9; P. B.-A., Nos. 620, 1278; *Tribonema bombycinum* Hazen, 1902, p. 184, Pl. XXV, figs. 1-3. Forming a yellowish or whitish floccose mass; filaments 6-11 $\mu$ diam., cells cylindrical or somewhat inflated, 2-4 diam. long; cell wall thin; chromatophores small or of moderate size, several in a cell. Fig. 4. Maine to No. Carolina; Alaska to Vancouver Island; probably everywhere. *Europe.*

A very common spring plant in roadside pools and brooks; the disk-shaped chromatophores distinguish it from *Microspora* and other filamentous algae of the same size, and the dimensions separate it fairly well from other species of *Conferva*.

Forma **tenuis** (Hazen) nov. comb.; *Tribonema bombycinum* forma *tenue* Hazen, 1902, p. 185, Pl. XXV, figs. 4-6; *Conferva bombycina* forma *minor* Wille, P. B.-A., No. 621. Cells 3-6 $\mu$ diam., 2-12 diam. long, little if any inflated; chromatophores several, small. Greenland, Maine to N. J. *Europe.*

A small, delicate, long-celled form, often found with the type; it is probably only a condition, but has quite a different appearance.

2. C. MINOR Klebs, 1896, p. 347, Pl. II, figs. 1-8; P. B.-A., No. 1327; *Tribonema minus* Hazen, 1902, p. 185, Pl. XXV, figs. 7 and 8. Cells cylindrical or very slightly inflated, 5-6 μ diam., 2-4 or even 6 diam. long; chromatophores 2 or 4 in a cell, arranged in pairs. Mass. to N. J. *Europe.*

In habit similar to *C. bombycina*, and in dimensions not unlike forms of that species, but quite distinct in the symmetrical arrangement of the 2 or 4 chromatophores.

3. C. UTRICULOSA Kützing, Decades, No. 114; Wolle, 1887, p. 140, Pl. CXX, figs. 14-16; P. B.-A., Nos. 1071 and 1223; *Tribonema utriculosum* Hazen, 1902, p. 186, Pl. XXV, figs. 9-11. Filaments 11-16 μ diam.; cells usually inflated, but somewhat irregularly, occasionally cylindrical, 1½-6 diam. long, rarely more; chromatophores large and often crowded; cell wall relatively thick. Mass. to N. J.; Jamaica. *Europe.*

Our largest species, having thicker cell walls and larger chromatophores than the others; the cells less uniform in size and shape; the Jamaica plant has cells up to 12 diam. long; like the other species chiefly a spring plant.

Many species originally included in *Conferva* will now be found under other genera; in some cases, however, the descriptions are not sufficiently full to determine the genus. Among the latter are *C. sesquipedale* Montagne, 1859, p. 173, from Louisiana; *C. antillarum* Kützing, 1853, p. 15, Pl. XLV, fig. 2, from Trinidad; *C. serpens* Kützing, 1849, p. 372; 1853, p. 15, Pl. XLVI, fig. 2, from Texas; *C. centrifuga* Agardh, 1854, p. 109, from Nicaragua.

## Family 2. BOTRYDIACEAE.

Unicellular, multinucleate, with numerous lens- or spindle-shaped chromatophores; with vesicular part above ground, rhizoidal part below; asexual reproduction by uniciliate zoospores, and by aplanospores.

Only one genus.

### BOTRYDIUM Wallroth, 1815, p. 153.

Frond stoutly clavate or globose, with branched lower portion containing protoplasm; asexual reproduction by uniciliate zoospores, formed in large numbers by simultaneous division of the cell contents, escaping by an opening at the summit; either developing into vegetative plants, or passing into resting spores with thick membrane, which later may develop vegetative plants.

Under special conditions round or ovoid aplanospores may be formed in large numbers in the root portions; these aplanospores may either produce zoospores, or grow directly into new plants.

After much confusion in regard to this genus, the studies of Rostafinski and Woronin, 1877, appeared to settle the matter, and since that time the genus has been considered as consisting only of a single species, exceedingly polymorphous in its adaptations to varying conditions. But the more recent investigations of Klebs, 1896, and Iwanoff, 1898, show that apparently at least three species must be distinguished, and one of these constitutes a new genus, *Protosiphon*. The other two species continue in *Botrydium*. There is no way of determining to which of these three species any record of *Botrydium granulatum* may refer; but fortunately all three species are included in the material distributed under that name in published American exsiccatae, and can be described here; few other localities than those of the exsiccatae can be given.

KEY TO THE SPECIES OF BOTRYDIUM.

1. Portion of cell above ground clavate with thin wall.
1. *B. granulatum*.

1. Portion of cell above ground spherical with thick, stratified wall.
2. *B. Wallrothii*.

1. B. GRANULATUM (L.) Greville, 1830, p. 196, Pl. XIX; Rostafinski and Woronin, 1877, p. 16, in part, Pl. I.; Wolle, 1887, p. 155, in part, Pl. CXXXI, figs. 1-9; P. B.-A., No. 226. Exposed portion 1-2 mm. diam., broadly clavate or obovoid, with bright green contents and thin wall, tapering below to the much branched subterranean portion; zoospores formed in the upper part, 10-20 × 5-8 $\mu$; aplanospores formed in the lower portion, globose or oblong, up to 50 $\mu$ diam. On moist ground, especially clay; probably generally distributed. Fig. 5. Mass., N. Y., Cal. *Europe, So. America, New Zealand.*

2. B. WALLROTHII Kützing, 1839, p. 387; *B. granulatum* Rostafinski and Woronin, 1877, p. 16, in part, Pl. III, figs. 25-28; Tilden, American Algae, No. 45, in part.

Exposed portion globose, rarely equalling 1 mm. diam., with dense, dark olive green contents and thick, much stratified membrane, passing without transition into the narrow, cylindrical underground portion, which for some distance is simple, then branching relatively slightly; the wall in the upper part of this portion is so thick as almost to close the opening. On moist ground. Minn. *Europe.*

The specimens distributed by Miss Tilden consist of this species in company with *Protosiphon botryoides* (Kütz.) Klebs.

Family 3. CHLOROTHECIACEAE.

Unicellular, attached; asexual reproduction by (uniciliate ?) zoospores formed one or more in a cell; sexual reproduction by (uniciliate ?) gametes formed one or more in the vegetative cell, or from cells developed in greater or less number within the vegetative cell; by union of these is formed a normal plant, either directly or by means of another generation of zoospores. In one genus there is a vegetative division of the cells, the daughter cells attached by gelatinous stalks in a tree-like colony. Fresh water plants. Only one genus represented here.

CHARACIOPSIS Borzi, 1894, p. 151.

Cells pyriform or ovoid, with several chromatophores, attached; erect or oblique, with longer or shorter stipe; asexual reproduction by uniciliate zoospores (possibly biciliate with one cilium much reduced) formed many in a cell, developing directly into a plant like the parent; sexual reproduction by the formation of numerous cells, with membrane, each producing 2-4 zoogametes, by whose conjugation is formed a resting zygote, ultimately developing into a plant like the parent.

In habit the species of this genus closely resemble species of *Characium*, but possess a sexual reproduction, and have zoospores with only one cilium or with merely the rudiment of a second cilium. In *Characium* there is only one chromatophore; in *Characiopsis* several chromatophores in a cell.

KEY TO THE SPECIES OF CHARACIOPSIS.

1. Without basal disk. 2.
1. With basal disk. 3.
 2. Cell ellipsoid with rounded summit. 3. *C. ellipsoidea.*
 2. Cell lanceolate with acute or apiculate summit. 2. *C. minuta.*
3. Stipitate, outline broadly lanceolate or ovate. 1. *C. acuta.*
3. Sessile, outline narrowly lanceolate, acuminate, more or less oblique. 4. *C. subulata.*

1. C. ACUTA (A. Br.) Borzi, 1894, p. 153; *Characium acutum* A. Braun, 1855, p. 41, Pl. V. C.; Wolle, 1887, p. 177, Pl. CLIX, fig. 2. Cell 15-20×6-10 μ, erect, straight, broadly lanceolate or ovate in outline, equally attenuate each way, subacute, opening at the top; stipe slender, 5-10 μ long, expanded below into a brownish disk. Pa. *Europe.*

2. C. MINUTA (A. Br.) Borzi, 1894, p. 152; *Characium minutum* A. Braun in Kützing, 1849, p. 892; 1855, p. 46, Pl.

V. F.; P. B.-A., No. 1221. Cell 17-25 × 5 $\mu$, lanceolate in outline, more or less oblique, subacute or apiculate, apiculum straight or curved; stipe short, base not expanded. Fig. 6. Mass., Cal. *Europe.*

3. C. ELLIPSOIDEA G. S. West, 1905, p. 288, Pl. CCCCLXIV, fig. 8. Cells 15-22 × 8-10 $\mu$, ellipsoid, apex obtusely rounded, stipe stout, very short, without basal disk; chromatophores 4. Barbados.

The stipe is so short that the cell might be considered practically sessile.

4. C. SUBULATA (A. Br.) Borzi, 1894, p. 152; P. B.-A., No. 1370; *Characium subulatum* A. Braun, 1855, p. 47, Pl. V. G. Cell 12-20 × 4-5 $\mu$, obliquely lanceolate, sessile, with no distinct stipe, but with sharply contracted base and basal disk; apex acuminate, more or less oblique; cells often gregarious, with confluent basal disks. Cal. *Europe.*

## Class II. CHLOROPHYCEAE.

Algae of true green color, usually producing starch, almost always with pyrenoid; reproduction in most cases by pyriform zoospores, with cilia of equal length, attached to the smaller end; mostly two, sometimes four, in a few genera many cilia; zoogametes of similar form, with two or four cilia.

Motionless spores of various kinds, and sexual reproduction by oogonia and antheridia, are found in many genera.

KEY TO THE ORDERS OF CHLOROPHYCEAE.

1. Frond of one or more cells. 2.
1. Frond usually of relatively large size, multinucleate, without distinction of cells. 6. SIPHONALES.
2. Vegetative cells ciliate and motile, always or except during resting periods, or easily passing into a motile condition. 2. VOLVOCALES.
2. Vegetative cells motionless; reproductive cells motile or not. 3.
3. Reproduction by zygospores formed by the union of two non-motile cells. 1. CONJUGALES.
3. Reproduction by zoospores, zoogametes or aplanospores, not by zygospores as above. 4.
4. Cells solitary or in spherical or net-like combinations. 3. PROTOCOCCALES.
4. Cells forming simple or branched filaments or membranes, rarely proliferously branching and vesicular cells. 5.
5. Cells uninucleate, chromatophore usually single, disk-, net-, or star-shaped. 4. ULOTRICHALES.

5. Cells multinucleate, chromatophore net-shaped, or of numerous small disks in a cell. 5. SIPHONOCLADIALES.

## Order I. CONJUGALES.

Grass-green algae, starch forming, with cell wall of cellulose, whose cells divide only in one direction, and are either isolated or in filaments; not incrusted with lime. Zygospores formed by the union of the protoplasm of two similar or only slightly different cells "aplanogametes"; after a longer or shorter resting period the outer membrane of the spore breaks, and a new vegetative development sets in. Thick-walled resting cells "akinetes" and asexual spores "aplanospores" sometimes formed; no motile spores.

The Conjugales are distributed all over the world, and seem more independent of geographic limitations than other algae. Of the 47 species of Zygnemaceae here described, all but three occur in Europe. While there is no such knowlege of these plants in Asia and Africa as there is in Europe and America, what species have been observed are very largely the familiar forms of the better explored regions. In view of this cosmopolitanism, any localities given must be considered as indicating where specimens have been found, not as limiting the range of distribution. All are plants of fresh water, only rarely extending into brackish water.

### KEY TO THE FAMILIES OF CONJUGALES.

1. Cells usually divided by a constriction into symmetrical halves; solitary or in filaments; the cell arising from the germinating zygospore either taking the normal form or producing 2-8 such forms. (DESMIDIACEAE.)
1. Cells cylindrical, without constrictions, always united in filaments; the new filament always formed directly from the zygospore. 2.
   2. The entire protoplasmic contents of the conjugating cells uniting to form the spore. 1. ZYGNEMACEAE.
   2. Only a part of the contents of the conjugating cells used for the spore. 2. MESOCARPACEAE.

The family Desmidiaceae is not included in this work. Rich in genera and species, it constitutes a special field apart from other algae, and for its proper presentation a special treatment would be needed. The two other families are closely related and distinctly marked off from all other green algae by the character of the fructification.

## Family 1. ZYGNEMACEAE.

Filaments sometimes attached, more generally free, all cells except the original basal cell equally capable of division ; filaments simple or rarely with short rhizoidal branches ; chromatophores of different shapes in the different genera ; zygospores formed by the union of the contents of two cells, either of the same filament (lateral conjugation), or of distinct filaments (scalariform conjugation) ; formed either in one of the two cells, or in the passage between them. Spore with membrane of three layers, of which the middle layer, mesospore, is the thickest and usually colored brown or yellow in the ripe spore, and often with pits or other markings. In germination the two outer layers are broken, the inner forming the membrane of the new plant, which at once divides into an indivisible basal cell, and a continuously divisible filament cell.

KEY TO THE GENERA OF ZYGNEMACEAE.

1. Two cells uniting to form one, before the formation of the spore. 2.
1. Each cell dividing ; spore then formed by the union of the two secondary cells. 4. ZYGOGONIUM.
  2. Chromatophores two, star-shaped. 1. ZYGNEMA.
  2. Chromatophores one or more, parietal, more or less spiral. 2. SPIROGYRA.
  2. Chromatophore an axial plate. 3. DEBARYA.

### 1. ZYGNEMA Agardh, 1814, p. 33.

Cells cylindrical, about as long as broad or somewhat longer ; dissepiments smooth and even ; two axillary stellate chromatophores in each cell, each with a pyrenoid, the nucleus between the two. Conjugation lateral or scalariform ; zygospore formed either in the connecting tube or in one of the cells ; spore with median membrane colored, either smooth or pitted ; outer membrane colorless, smooth or with prominences. Aplanospores formed in unchanged vegetative cells and similar in appearance to zygospores. Akinetes formed from single cells taking on a thicker membrane and richer contents ; both aplanospores and akinetes exceptional.

KEY TO THE SPECIES OF ZYGNEMA.

1. Spore formed in the tube. Sect. PECTINATA. 2.
1. Spore formed in one of the cells. 4.
  2. Spore with thick, lamellate membrane. 2. *Z. pachydermum.*
  2. Spore without thick lamellate membrane. 3.
3. Spore bluish. 3. *Z. cyanospermum.*
3. Spore brownish. 1. *Z. pectinatum.*
  4. Spore with smooth median membrane. Sect. LEIOSPERMA. 5.

4. Spore with pitted median membrane. Sect. SCROBICULATA. 7.
5. Spore bluish. 4. *Z. chalybeospermum.*
5. Spore brownish. 6.
6. Vegetative filaments 20-22 $\mu$ diam. 5. *Z. leiospermum.*
6. Vegetative filaments 26-30 $\mu$ diam. 6. *Z. insigne.*
7. Spores uniformly globose. 7. *Z. cruciatum.*
7. Spores usually oblong. 8. *Z. stellinum.*

1. Z. PECTINATUM (Vauch.) Agardh, 1817, p. 102; De Bary, 1858, p. 77, Pl. I, figs. 15-19; Pl. VIII, Fig. 13; *Zygogonium pectinatum* Wolle, 1887, p. 225, Pl. CXLV, figs. 1 and 2; P. B.-A., No. 1216. Vegetative cells 30-37 $\mu$ diam., 1-3 diam. long; membrane at first thin, later with a thick, gelatinous sheath; conjugation scalariform; spores globose or broadly ellipsoid, about 50 $\mu$ diam.; membrane brown, distinctly pitted. Mass., N. J. *Europe, So. America.*

Var. ANOMALUM (Ralfs) Kirchner, 1878, p. 126; *Z. anomalum* var. *crassum* Wolle, 1887, p. 224, Pl. CXLIV, figs. 9-13. Cells 40-50 $\mu$ diam.; membrane very thick. Vermont, Mass., Conn. *Europe.*

Var. DECUSSATUM (Vauch.) Kirchner, 1878, p. 127; P. B.-A., 1415. *Zygogonium decussatum* Wolle, 1887, p. 226, Pl. CXLV, figs. 4 and 5. Cells 18-20 $\mu$ diam., membrane not conspicuously gelatinous. Mass.; "Ponds, stagnant and sluggish water." Wolle. *Europe.*

Forma TERRESTRE (Rab.) Kirchner, 1878, p. 127; P. B.-A., No. 1365. Membrane thick, dark-colored, cell shorter than in the type; on ground along the edges of ponds. Mass. *Europe.*

2. Z. PACHYDERMUM W. and G. S. West, 1895, p. 266, Pl. XII, figs. 1-16. Filaments flexuous, somewhat geniculate; vegetative cells 16-23 $\mu$, usually 20 $\mu$ diam., 2-3 diam. long; membrane up to 5 $\mu$ thick; short, irregular, rhizoidal branches of 2-6 cells frequent; conjugation scalariform; spores globose, subglobose, ellipsoid or of irregular shape, 25-35 $\times$ 19-26 $\mu$; membrane up to 6 $\mu$ thick, lamellate; aplanospores similar but somewhat smaller and with thinner membrane. In warm muddy water. Dominica.

Var. CONFERVOIDES W. and G. S. West, 1895, p. 266, Pl. XIV, figs. 1-6. Cells 10-13 $\mu$ diam., 1-2 diam. long; reproduction unknown. With the type.

The irregularly formed spores with thick, lamellate walls may be a result of the peculiar thermal conditions under which this species occurs; but it can hardly be considered as a form of any other of our species.

3. Z. CYANOSPERMUM Cleve, 1868, p. 28, Pl. VIII, figs. 6-8. Vegetative cells about 20 μ diam., 2-9 diam. long; conjugation scalariform; spores globose, 34-40 μ diam., in the short tube; membrane bluish, smooth. Greenland.
*Northern Europe.*

4. Z. CHALYBEOSPERMUM Hansgirg, 1888a, p. 257; P. B.-A., No. 808. Vegetative cells 24-27 μ diam., 1-3 diam. long, fertile cells shorter; membrane delicate; conjugation scalariform; spores globose or subglobose, about 35 μ diam.; median membrane bluish, smooth; cells containing spore somewhat inflated. Cal. *Europe.*

5. Z. LEIOSPERMUM De Bary, 1858, p. 77, Pl. I, figs. 7-14; Wolle, 1887, p. 222, Pl. CXLIII, figs. 1-3; Rabenhorst, Algen, No. 638. Vegetative cells 20-22 μ diam., as long or slightly more; conjugation scalariform or lateral; fertile cells somewhat swollen and shortened; spores smooth, globose or broadly ovoid, brownish, 23-30 μ diam., escaping from the cell before fully ripe. Greenland, Mass. *Europe.*

6. Z. INSIGNE (Hass.) Kützing, 1849, p. 444; 1855a, p. 5, Pl. XVII, fig. 1; De Bary, 1858, p. 78, Pl. VIII, figs. 14-16; Wolle, 1887, p. 223, Pl. CXLIII, figs. 4-6; P. B.-A., No. 457. Vegetative cells 26-30 μ diam., length equal to diam. or up to 2 diam.; cylindrical or swollen on one side; conjugation scalariform or lateral; spores 30-32 μ diam., brownish, remaining enclosed after maturity by the persistent cell wall. Mass., N. J., Cal. *Europe.*

Differs from the preceding species chiefly in dimensions, but also by the different behavior of the ripe spore.

7. Z. CRUCIATUM (Vauch.) Agardh, 1817, p. 102; Kützing, 1855a, p. 5, Pl. XVII, fig. 4; Wolle, 1887, p. 224, Pl. CXLIV, figs. 1 and 2; P. B.-A., No. 758. Vegetative cells 35-54 μ diam., as long or somewhat longer; conjugation scalariform; spores globose, brown, about 40 μ diam., median membrane finely punctate; fertile cells not swollen. Mass., N. J.
*Europe, So. America.*

8. Z. STELLINUM (Müller) Agardh, 1824, p. 77; Wolle, 1887, p. 223, Pl. CXLIII, figs. 7-17; P.B.A., No. 1172. Vegetative cells 25-36 μ diam., 1-3 diam. long; conjugation scalariform or lateral; spores ovoid or oblong, 35-48 × 30-35 μ, brown, median membrane with rounded pits; fertile cells hardly swollen. Fig. 7. Greenland, Mass., Conn., N. J. *Europe.*

The dimensions are for the type; a number of forms have been described, in some of which the cell diameter does not exceed 10 $\mu$. The larger forms are distinguished from *Z. cruciatum* chiefly by the form of the spores, ovoid rather than globose; also by the somewhat coarser marking of the membrane.

2. SPIROGYRA Link, 1820, p. 5.

Cells cylindrical, once to many times as long as broad; dissepiments either smooth and even or with ring-like projections; chromatophores one or more in a cell, in the form of parietal, more or less spirally bent, broad or narrow bands, each containing several pyrenoids; nucleus in the middle of the cell. Conjugation lateral or scalariform; spore formed in one of the two conjugating cells; median membrane colored, smooth or pitted; germinating spore producing a more or less clavate filament.

A genus of many species, of world-wide distribution; the specific distinctions not always clear, based on the character of the dissepiments, the number and breadth of the chromatophores, the size and form of the spore, the character of its median membrane, the inflation of the fertile cell, and, too often, the dimensions of the filaments; this last character being too uncertain to have much weight, except when associated uniformly with other characters. The size and shape of the spore is of more importance, but it must be kept in mind that a change of position in the cell may give a totally different aspect to the spore when seen under the microscope. An ovoid spore appears circular when its axis is in the line of vision; and a lenticular spore varies from circular to a quite narrow oval, according to the angle at which it is seen. Good plates are of the utmost use in determining species of *Spirogyra*; the best work available is Petit, 1880. Of the 37 species there figured, 32 are given in the following pages, and there is no reason why the remaining five should not be expected in America. In addition to the zygospores, parthenospores are sometimes formed, the usual process not extending to the union of the tubes from the two cells; spores formed in one or both of the filament cells. Aplanospores occasionally formed, as in *Zygnema*.

The following key may be of assistance in determining species, but in a rather general way.

KEY TO THE SPECIES OF SPIROGYRA.

1. Cell conjugating directly, not by a tube. 38. *S. stictica.*
1. Cell emitting a tube. 2.

2. Dissepiments plane. 3.
2. Dissepiments replicate. 27.
3. Chromatophore single. 4.
3. Chromatophores two or more. 16.
4. Spore membrane punctate. 27. *S. punctata.*
4. Spore membrane smooth. 5.
5. Fertile cells not distinctly swollen. 6.
5. Fertile cells distinctly swollen. 10.
6. Cells less than 30 $\mu$ diam. 7.
6. Cells 30 $\mu$ diam. or more. 9.
7. Spore ovoid, slightly longer than the diam.; cells 22-25 $\mu$ diam. 9. *S. subsalsa.*
7. Spore ellipsoid, 2-3 times as long as the diam. 8.
8. Chromatophore slender, with inconspicuous pyrenoids. 7. *S. communis.*
8. Chromatophore slender, with many large, distinct pyrenoids. 3. *S. Juergensii.*
8. Chromatophore broad. 1. *S. longata.*
9. Cells 30-48 $\mu$ diam. 2. *S. porticalis.*
9. Cells 48-70 $\mu$ diam. 8. *S. condensata.*
10. Fertile cells swollen on one side only. 11.
10. Fertile cells swollen on both sides. 12.
11. Cells 18-22 $\mu$ diam. 21. *S. gracilis.*
11. Cells 33-40 $\mu$ diam. 5. *S. varians.*
12. Chromatophore slender. 13.
12. Chromatophore broad. 14.
13. Cells 27-30 $\mu$ diam.; spore $30\text{-}33 \times 33\text{-}45$ $\mu$. 18. *S. affinis.*
13. Cells 40-45 $\mu$ diam.; spore about 47 $\mu$ diam., of varying shape. 6. *S. fusco-atra.*
14. Cells 11-13 $\mu$ diam.; spore about $20 \times 30$ $\mu$. 20. *S. flavescens.*
14. Cells 24-27 $\mu$ diam. 15.
14. Cells 30-43 $\mu$ diam.; spore $30\text{-}42 \times 70\text{-}120$ $\mu$. 22. *S. lutetiana.*
15. Spore $30 \times 60\text{-}75$ $\mu$. 4. *S. catenaeformis.*
15. Spore $24\text{-}26 \times 38\text{-}50$ $\mu$, formed without conjugation. 19. *S. mirabilis.*
16. Chromatophores two, rarely three. 17.
16. Chromatophores regularly three or more. 18.
17. Cells 27-40 $\mu$ diam. 10. *S. decimina.*
17. Cells 43-50 $\mu$ diam. 26. *S. dubia.*
18. Spore lenticular. 19.
18. Spore ovoid, ellipsoid or subglobose. 21.
19. Cells 100 $\mu$ diam. or more. 16. *S. maxima.*
19. Cells less than 100 $\mu$ diam. 20.
20. Fertile cells little or not swollen. 15. *S. orthospira.*
20. Fertile cells distinctly swollen. 25. *S. bellis.*
21. Cells 90-160 $\mu$ diam. 22.

21. Cells 80 $\mu$ diam. or less. 23.
22. Cells 150-160 $\mu$ diam.; chromatophores many. 17. *S. crassa.*
22. Cells 100-110 $\mu$ diam.; chromatophores 4-8. 13. *S. setiformis.*
22. Cells 90-100 $\mu$ diam.; chromatophores 3-4. 12. *S. jugalis.*
23. Cells less than 40 $\mu$ diam. 24.
23. Cells 50-80 $\mu$ diam. 25.
24. Chromatophores 4. 24. *S. fluviatilis.*
24. Chromatophores 3, rarely 2; plant of brackish water. 10. *S. decimina var. submarina.*
25. Cells 50-65 $\mu$ diam. 23. *S. ternata.*
25. Cells 70-78 $\mu$ diam. 26.
26. Spore 60-72 $\mu$ diam. 11. *S. nitida.*
26. Spore about 50 $\mu$ diam. 14. *S. parvispora.*
27. Chromatophore single. 28.
27. Chromatophores two or more. 34.
28. Spore membrane punctate. 37. *S. protecta.*
28. Spore membrane smooth. 29.
29. Fertile cells little if any swollen. 32. *S. Weberi.*
29. Fertile cells distinctly swollen. 30.
30. Filaments 9-23 $\mu$ diam. 31.
30. Filaments 24-33 $\mu$ diam. 33.
31. Inflation cylindrical. 34. *S. groenlandica.*
31. Inflation rounded or tapering at the ends. 32.
32. Cells 9-12 $\mu$ diam.; 4-15 times as long. 28. *S. tenuissima.*
32. Cells 15-18 $\mu$ diam.; 3-8 times as long. 29. *S. inflata.*
32. Cells 18-21 $\mu$ diam.; 10-25 times as long. 30. *S. Spreeiana.*
33. Cells 24-30 $\mu$ diam.; fertile cells quadrately swollen. 31. *S. quadrata.*
33. Cells 28-33 $\mu$ diam.; fertile cells somewhat rounded. 33. *S. Grevilleana.*
34. Cells 30-33 $\mu$ diam.; chromatophores broad. 35. *S. Hassallii.*
34. Cells 39-42 $\mu$ diam.; chromatophores slender. 36. *S. insignis.*

Subgenus EUSPIROGYRA; conjugation by means of a tube.

Section CONJUGATA; dissepiments plane.

Subsection DIPLOZYGA; each cell emitting a tube.

1. S. LONGATA (Vauch.) Kützing, 1843, p. 279; Petit, 1880, p. 20, Pl. V, figs. 4 & 5; Wolle, 1887, p. 214, Pl. CXXXV, figs. 9 & 10; P. B.-A., No. 510. Filaments 20-36 $\mu$ diam., cells 2-10 diam. long, chromatophore single, broad, bright green, making 2-5 turns in the cell; fertile cells not swollen; spores broadly ovoid with rounded ends, pale yellow at maturity, twice as long as broad, entirely filling the width of the cell. Mass., R. I., N. J., Colorado. *Europe*, *So. America.*

The perfectly cylindrical form of the fertile cells, barely large enough to contain the spores, distinguishes this species from others of the same general dimensions.

2. S. PORTICALIS (Müller) Cleve, 1868, p. 22, Pl. V, figs. 8-13; Petit, 1880, p. 21, Pl. V, figs. 8-12; P. B.-A., No. 365; *S. quinina* Wolle, 1887, p. 213, Pl. CXXXIV, figs. 14-17. Filaments 30-48 $\mu$ diam., cells 2-6 diam. long; chromatophore single, quite broad, dentate, bright green, making 3-4 turns in the cell; fertile cells little or not at all swollen; spores ovoid or subglobular, yellowish at maturity, 1½ diam. long; diam. up to 42 $\mu$. Mass., N. J., Pa., Iowa, Cal.

*Europe, Asia, So. America.*

A very common species, often forming extensive yellow-green masses in quiet water; very mucilaginous; the broad, dentate spiral, with many brilliant pyrenoids, is characteristic.

Forma MINOR Collins, P. B.-A., No. 1263. Filaments about 42 $\mu$ diam.; spores 30-35 $\mu$ diam. Conn.

3. S. JUERGENSII Kutzing, 1845, p. 222; Petit, 1880, p. 16, Pl. V, figs. 6 & 7; Wolle, 1887, p. 213, Pl. CXLII, figs 3 & 4; Rabenhorst, Algen, No. 1534. Filaments 24-26 $\mu$ diam.; cells 2½-5 diam. long; chromatophore single, slender, delicate green, with pyrenoids much broader than the spiral; fertile cells slightly swollen, but no more than caused by the spores; spores 30 $\mu$ diam., ellipsoid, twice as long as broad, golden color at maturity. Cal.; according to Wolle, generally distributed.

*Europe.*

Nearly allied to *S. porticalis* and *S. communis*; differing from the former by smaller dimensions throughout; from the latter by the different chromatophore, and by the shorter and stouter spore.

4. S. CATENAEFORMIS (Hass.) Kützing, 1849, p. 438; Petit, 1880, p. 17, Pl. III, figs. 9-12; P. B.-A, No. 361. Filaments 24-27 $\mu$ diam., cells 2-5½ diam. long; chromatophore single, quite broad, dentate, making 1-6 turns in the cell; fruiting cell swollen, up to 36 $\mu$ diam.; spores ellipsoid with rounded ends, yellowish at maturity, 2-2½ times as long as broad, up to 30 $\mu$ diam. Mass., Cal. *Europe.*

A quite variable species, but not difficult of recognition by the combination of characters just given.

5. S. VARIANS (Hass.) Kützing, 1849, p. 439; Petit, 1880, p. 19, Pl. IV, figs. 1-8; Wolle, 1887, p. 212, Pl. CXXXIV, figs. 8-13; P. B.-A., Nos. 367, 962. Filaments 33-40 $\mu$ diam., cells 2-3 diam. long; chromatophore single, quite broad, den-

tate or serrate, making 1-3 turns in the cell; fertile cells swollen only on the side of the conjugation; cells in filament which have not conjugated often much swollen and distorted; spores ovoid or ellipsoid, 1½-2½ diam. long; diam. 33-38 μ. Me., Mass., N. Y., N. J., Iowa, Wash., Cal. *Europe, So. America.*

A polymorphous species, but no other species of about the same dimensions has the unilaterally inflated cells, and the irregularly inflated vegetative cells.

6. S. FUSCO-ATRA Rabenhorst, Algen, No. 98; Wolle, 1887, p. 215, Pl. CXL, figs. 4-7. Filaments 40-45 μ diam., cells 2-4 diam. long; cylindrical or slightly constricted at the nodes; becoming blackish with age, and purplish in the dried specimen; chromatophore single, making 2-3 turns in the cell; spores polymorphous, globose, ellipsoid, oblong or cylindrical, 40-47 μ diam. Pa. *Europe.*

This species is included with some doubt; the description by Wolle is meager and the plate little more satisfactory; no other American record is known. No mention is made of the blackish or purplish brown color at maturity, from which it has its name, and neither plate nor description indicates the collapsed cells surrounding the ripe spores. The two-spired filament in the figure is also suspicious.

7. S. COMMUNIS (Hass.) Kützing, 1849, p. 439; Petit, 1880, p. 16, Pl. V, figs. 1-3; Wolle, 1887, p. 213, Pl. CXLII, figs. 1 and 2; P. B.-A., No. 1416. Filaments 20-25 μ diam., cells 3-5 diam. long; chromatophore single, quite slender, making 1½-4 turns in the cell; fertile cells not at all swollen; spores ellipsoid with pointed ends, yellowish at maturity, 19-23 μ diam., 2-3 times as long. Mass., N. J. *Europe, So. America.*

Often forming dense masses of dark green color in quiet water; soft to the touch but not mucilaginous; best characterized by the uninflated fertile cells and by the long spores with pointed ends.

8. S. CONDENSATA (Vauch.) Kützing, 1843, p. 279; Petit, 1880, p. 22, Pl. IX, figs. 6-8; Wolle, 1887, p. 215; Wittr. and Nordst., Alg. Exsicc., No. 247. Filaments 48-54 μ diam., cells as long as broad, or slightly longer or shorter; chromatophore single, slender, with large pyrenoids making ½-1½ turns in the cell; fertile cell not inflated; spores ellipsoid, 1½ diam. long, up to 36 μ diam., conjugation usually lateral. *Europe, So. America.*

Var. RUSBYI Wolle, 1887, p. 215, Pl. CXXXIX, figs. 7-9. Filaments 62-75 $\mu$ diam.; otherwise like the type. New Mex., N. J.?

It is not clear from Wolle's account whether he had observed the type in this country, or only the var. *Rusbyi*. The N. J. reference is in any case doubtful, only sterile plants having been observed.

9. S. SUBSALSA Kützing, 1845, p. 222; Wolle, 1887, p. 212, Pl. CXLI, figs. 3 and 4. Filaments 22-25 $\mu$ diam., cells 1-1½ diam. long; chromatophore single, making 1½-3 turns in the cell; fertile cells little or not at all swollen; spore ovoid, slightly longer than the diam.; diam. 18-20 $\mu$. Florida. *Europe.*

Included with some doubt; the locality is not indicated as brackish.

10. S. DECIMINA (Müller) Kützing, 1843, p. 279; Petit, 1880, p. 25, Pl. VIII, figs. 1-3; Wolle, 1887, p. 216, Pl. CXXXV, figs. 5 and 6; Wittr. and Nordst., Alg. Exsicc., No. 1372. Filaments 34-40 $\mu$ diam., cells 2-4 diam. long; chromatophores 2, rarely 3, quite broad, making 1-2 turns in the cell; fertile cells not swollen; spores broadly ovoid or almost globular, $38 \times 42\text{-}75\ \mu$, as broad as the filament. Mass., Pa., Iowa, Jamaica, St. Croix. *Europe, Africa.*

Rather common; usually occurring in large masses, very mucilaginous.

Var. TRIPLICATA Collins, P. B.-A., No. 960. Chromatophores uniformly three; spores $34\text{-}48 \times 48\text{-}54\ \mu$; otherwise like the type. Mass., Cal.

Var. **Submarina** n. var. Filaments 27-32 $\mu$ diam., cells 3-6 diam. long; chromatophores 2 or 3, making 1½-3 turns in the cell; spores ellipsoid, 2-3 diam. long, $31\text{-}37 \times 56\text{-}120\ \mu$; fertile cells swollen just enough to hold the spore. Mass., Conn.

Perhaps a good species, but having so many resemblances to *S. decimina* as to indicate that the differences may be due to the station, salt marsh and brackish pools, an unusual one for a *Spirogyra*. The principal distinctions are in the slender filaments, longer cells, longer spores and somewhat swollen fertile cells.

11. S. NITIDA (Dillw.) Link, 1833, p. 262; Petit, 1880, p. 28, Pl. X, figs. 6-10; Wolle, 1887, p. 217, Pl. CXXXVII, figs. 7 and 8; P. B.-A., No 513. Filaments 72-78 $\mu$ diam., cells 1½-3 diam. long; chromatophores usually 5, more or less

broad, sometimes straight and parallel, sometimes making a single turn in the cell; fertile cells little or not at all swollen; spores ellipsoid with tapering ends, yellowish at maturity, 1½-2 diam. long, diam. 60-72 μ. Mass., Conn., N. J., Iowa, Cuba. *Europe, Africa.*

Forms dark green, very mucilaginous masses; filaments crisp and shining, when taken from the water. *S. diluta* Wood, 1872, p. 170, Pl. XV, fig. 2, should probably be included in this species.

12. S. JUGALIS (Fl. Dan.) Kützing, 1845, p. 223; Petit, 1880, p. 28, Pl. XI, figs. 3 and 4; Wolle, 1887, p. 219, Pl. CXXXVIII, figs. 7 and 8; Rabenhorst, Algen, No. 1049. Filaments 90-100 μ diam. at the nodes, cells 1-1½ diam. long, usually swollen near the middle and there reaching 115 μ diam., chromatophores 3 or 4, quite broad, pale green, finely dentate, with many large pyrenoids, and making 1-2 turns in the cell; fertile cells of the same form; spores ovoid, brown at maturity, 1½ diam. long, diam. 100-110 μ. Mass. *Europe.*

Not uncommon, forming dense masses of a handsome green, hardly at all mucilaginous; filaments firm and crisped, large enough to be visible singly. The swollen vegetative cells give the most striking character.

13. S. SETIFORMIS (Roth) Kützing, 1845, p. 223; Petit, 1880, p. 29, Pl. XI, figs. 1 & 2; Wolle, 1887, p. 219, Pl. CXXXVIII, figs. 1-4; Wittr. & Nordst., Alg. Exsicc., No. 747. Filaments 100-110 μ diam., cells about as long as broad, sometimes nearly 2 diam. long; 4 rather broad chromatophores, irregular, with sinuate margins and many large pyrenoids, making ½-1 turn in the cell; fertile cells not swollen; spores ellipsoid, diam. 96-100 μ. Mass., Pa., N. J. *Europe.*

Quite near *S. jugalis*, but without the swollen vegetative cells, with narrower and more irregular spirals, and somewhat smaller spore.

14. S. PARVISPORA Wood, 1869, p. 139; 1872, p. 169, Pl. XV, fig. 7; Wolle, 1887, p. 221, Pl. CXL, figs. 8 & 9. Filaments about 75 μ diam., cells 2-4 diam. long; chromatophores 4, narrow, making 1½ turns in the cell; fertile cells not swollen; spores ellipsoid, about 1½-2 diam. long, diam. about 50 μ. Florida.

Quite distinct by the small size of the spores in proportion to the cells. There appears to be no record of it but the original description.

15. S. ORTHOSPIRA Nägeli in Kützing, 1849, p. 441; Petit, 1880, p. 30, Pl. X, figs. 4 and 5; Wolle, 1887, p. 218, Pl. CXXXVI, figs. 10-11; *S. majuscula* P. B.-A., No. 511. Filaments 60-66 $\mu$ diam., cells 2-3 diam. long; chromatophores 7 or 8, very slender, pale green, usually straight and parallel, sometimes inclined and making a quarter turn in the cell; fertile cells little or not at all swollen; spores at maturity brown, lenticular, about 72 $\mu$ diam., by 48 $\mu$ thick. Mass., N. Y., Pa., Minn., Dakota. *Europe, So. America.*

Usually in scattered filaments among other algae; while in each of its characters it resembles some other species, there is no one which combines the characters of numerous, slender, straight or nearly straight chromatophores, and lenticular spores, not over 72 $\mu$ diam. As No. 285 of Tilden, American Algae, is distributed, under the name of *S. majuscula* var. *brachymeres*, a plant agreeing with *S. orthospira*, except that the cells are somewhat larger. No spores were found in the specimen examined, and it seems safer to include it under the type of the species.

16. S. MAXIMA (Hass.) Wittrock, 1882, p. 57; Wolle, 1887, p. 218, Pl. CXXXIX, figs. 3 and 4; P. B.-A., No. 512; *S. orbicularis* Petit, 1880, p. 31, Pl. XII, figs. 1 and 2; P. B.-A., No. 1018. Filaments 130-140 $\mu$ diam., occasionally as low as 118 $\mu$; cells as long as the diam. or slightly more or less; chromatophores 6 or 7, narrow, pale, very finely dentate, with large pyrenoids, making half or three-quarters of a turn in a cell; fertile cells not swollen; spores lenticular, brown at maturity, about 100-115 $\mu$ diam., by 77-84 $\mu$ thick. Pa., Cal. *Europe, So. America.*

The size of the filaments given above is the usual dimension, but considerably larger or smaller are found, in exceptional cases; the American specimens seem to be usually smaller than the European.

Var. INAEQUALIS Wolle in Wittr. and Nordst., Alg. Exsicc., No. 541; 1887, p. 218, Pl. CXXXVIII, figs. 5 and 6. Sporiferous filaments about 80 $\mu$ diam., conjugating with filaments about 125 $\mu$ diam., spores not wider than the cells in which they occur. Pa.

Wittrock and Nordstedt suggest, Fasc. 21, p. 31, that this is possibly a hybridization of two species.

17. S. CRASSA Kützing, 1843, p. 280, Pl. XIV, fig. 4;

Petit, 1880, p. 32, Pl. XII, figs. 3 and 4; Wolle, 1887, p. 219, Pl. CLX, figs. 1-3; Phyk. Univ., No. 440. Filaments 150-160 $\mu$ diam., cells 1-2 diam. long; chromatophores numerous, rarely as few as 4, often 10; not parallel, rather slender, sinuate at the margin, with very small pyrenoids, making ½-1 turn in the cell, or sometimes nearly straight; fertile cells not swollen; spores broadly ovoid and flattened, about 1½ diam. long, diam. 140-150 $\mu$. Mass., Pa., N. J., Iowa. *Europe, So. America.*

The largest species of the genus, the individual filaments quite distinct to the eye, firm and crisped, somewhat mucilaginous.

18. S. AFFINIS (Hass.) Petit, 1880, p. 18, Pl. III, figs. 13-14; P. B.-A., No. 959. Filaments 27-30 $\mu$ diam., cells 1½-3 diam. long; chromatophore single, quite slender, making 1-3½ turns in the cell, often forming only a single ring; fertile cells much swollen, often nearly or quite spherical; spores ellipsoid, 1-1½ diam. long, up to 30 $\mu$ diam. Lateral conjugation more common than scalariform. Jamaica, Alaska. *Europe.*

Quite distinct by the uniformly short vegetative cells, and the bullate fertile cells.

19. S. MIRABILIS (Hass.) Kützing, 1849, p. 438; Petit, 1880, p. 14, Pl. III, figs. 3 and 4; Wolle, 1887, p. 211, Pl. CXXXIV, figs. 1 and 2; Wittr. and Nordst., Alg. Exsicc., No. 1377. Filaments 24-27 $\mu$ diam., cells 4-10 diam. long; chromatophore single, quite broad, making 4-7 turns in the cell; fertile cells swollen, even before the formation of the spores, which are ovoid or ellipsoid, 24-26 $\mu$ diam., 1½-2 diam. long; and are formed without any observable conjugation, either lateral or scalariform. Maine, Wis. *Europe, Asia.*

The spores of this species, though in appearance like zygospores, are more properly to be considered aplanospores.

20. S. FLAVESCENS (Hass.) Kützing, 1849, p. 438; Petit, 1880, p. 15, Pl. III, figs. 5 and 6; Wolle, 1887, p. 211, Pl. CXXXIV, figs. 3 and 4; Rabenhorst, Algen Sachsens, No. 60. Filaments 11-13 $\mu$ diam., cells 3-4 diam. long; chromatophore single, quite broad, yellowish green, making 1-2 turns in the cell; fertile cells swollen; spores ovoid with rounded ends, yellowish when mature, 20 $\mu$ diam., 1½ diam. long. Florida. *Europe.*

Possibly only a variety of the following species, from which it differs chiefly in its smaller diameter, and in the different form of the fertile cells. Wolle gives a larger diameter for the filaments than that noted above; his plant seems intermediate between *S. flavescens* and *S. gracilis*.

21. S. GRACILIS (Hass.) Kützing, 1849, p. 438; Petit, 1880, p. 15, Pl. III, figs. 7 and 8; Wolle, 1887, p. 211, Pl. CXXXIV, figs. 5-7, P. B.-A., No. 1418. Filaments 18-21 μ diam.; cells 3-5 diam. long; chromatophore single, quite broad, rich green, making 1½-3 turns in the cell; fertile cells swollen only on the conjugating side, the other remaining straight; spores ovoid, yellowish at maturity, diam. about 30 μ, length about double. Mass., Michigan. *Europe.*

22. S. LUTETIANA Petit, 1879, p. 97, Pl. VI; 1880, p. 21, Pl. IV, figs. 9-13; Wolle, 1887, p. 214, Pl. CXXXV, figs. 7 and 8; P. B.-A., No. 1065. Filaments 30-36 μ diam., cells 3-7 diam. long; chromatophore single, broad, dentate, dark green, making 3-7 turns in the cell; fertile cells sometimes swollen, sometimes cylindrical; spores polymorphous, globular, ellipsoid, oblong, cylindric-ellipsoid, pyriform or reniform; yellowish at maturity, 2-4 diam. long; diam. 30-43 μ. Mass., Washington, Florida? *Europe.*

The most distinctive character of this species is found in the polymorphous spores. Wolle's description of the Florida plant leaves considerable doubt as to its identity with Petit's species.

23. S. TERNATA Ripart, 1876, p. 162; Petit, 1880, p. 26, Pl. VIII, figs. 4-7; Tilden, American Algae, No. 159, as *S. neglecta*. Filaments 50-65 μ diam., cells 1½-2 diam. long, somewhat swollen at the middle; chromatophores three, narrow, with apparent middle line uniting the pyrenoids, making 1½-2 turns in the cell; fertile cells swollen and shortened, often shorter than the diam., so that the spores are turned at right angles to their usual position; spores ovoid, 45-66 μ diam., 1-1½ diam. long. Ill., Colorado. *Europe.*

This species is nearly allied to *S. neglecta*, but the cells are shorter, especially the fertile cells, and the spores are often so closely set that they are side by side, their longer axes at right angles to the direction of the filament.

24. S. FLUVIATILIS Hilse in Rabenhorst, Algen, No. 1476; Petit, 1880, p. 27, Pl. V, fig. 13; Wolle, 1887, p. 216, Pl. CXXXVI, figs. 1-3; P. B.-A., Nos. 1217, 1417. Filaments 36 μ diam., cells 5-6 diam. long; chromatophores 4, slender, very pale green, making 1½-2½ turns in the cell; fertile cells swollen and shortened; spores ovoid, about 50 × 80 μ. Mass., Pa. *Europe.*

No spores have been reported from the European localities, and Wolle's statement as to Pennsylvania localities was the first record for spores of this species; in Massachusetts it was found sterile, attached to stones, also floating, with spores like those figured by Wolle.

25. S. BELLIS (Hass.) Cleve, 1868, p. 18, Pl. III, figs. 2-5; Petit, 1880, p. 31, Pl. X, figs. 1-3; Wolle, 1887, p. 217, Pl. CXXXVII, figs. 5 and 6; Pl. CXXXIX, figs. 1 and 2; P. B.-A., No. 359. Filaments 65-80 μ diam., cells 1½-3 diam. long; chromatophores 5 or 6, narrow, with large prominent pyrenoids; almost straight, or making half to three-quarters of a turn in a cell; fertile cells swollen and shortened; swelling sometimes only on the side opposite to the conjugation; spores brown at maturity, lenticular, diam. 84-90 μ, thickness 55-60 μ. Mass., N. J., Pa. *Europe.*

26. S. DUBIA Kützing, 1855a, p. 8, Pl. XXIV, fig. 4; Wolle, 1887, p. 220, Pl. CXXXV, figs. 11 and 12. Filaments 43-50 μ diam., cells 1½-2½ diam. long; chromatophores 2, rarely 3, narrow, making 1-3 turns in the cell; fertile cells slightly swollen; spores brownish at maturity, ovoid-ellipsoid, about 40 μ diam., 1-2 diam. long. Mass., Pa. *Europe.*

Var. LONGIARTICULATA Kützing, 1855a, p. 8, Pl. XXV, fig. 1; Wolle, 1887, p. 220; P. B.-A., No. 961. Cells 5 diam. long; chromatophores 2 or 3. British Columbia. *Europe.*

Subsection MONOZYGA; only one cell emitting a tube.

27. S. PUNCTATA Cleve, 1868, p. 23, Pl. VI, figs. 1-4; Petit, 1880, p. 24, Pl. IX, figs. 9-11; Wolle, 1887, p. 215, Pl. CXLI, figs. 5-7. Filaments 24-27 μ diam., cells 6-12 diam. long; chromatophore single, rather slender, with few pyrenoids, making 4-7 turns in the cell; fertile cells swollen and shortened; tube issuing from only one of the conjugating cells, broadening until it reaches the surface of the other cell; spores ellipsoid, yellowish at maturity, 1½-2 diam. long, about 36 μ diam.; median membrane finely punctate. N. J. *Europe, Asia.*

The punctate membrane and the peculiar formation of the tubes amply distinguish this from all our other species. The latter character shows a more distinct sexual differentiation than in other species of the genus.

Section 2. SALMACIS; Dissepiments replicate.

28. S. TENUISSIMA (Hass.) Kützing, 1849, p. 437; Petit, 1880, p. 6, Pl. I, figs. 1-3; Wolle, 1887, p. 207, Pl. CXXXII, figs. 1-3; P. B.-A., No. 456. Filaments 9-12 μ diam., cells 4-12 diam. long; chromatophore single, slender, making 3-5½

turns in the cell; fertile cells much swollen, vesicular, not shortened, extreme diam. 37-42 μ; spores ellipsoid, yellow at maturity, 2 diam. long, diam. about 30 μ. Mass., R. I.
*Europe, New Zealand.*

The smallest of our species and easily recognized.

29. S. INFLATA (Vauch.) Kützing, 1843, p. 279; Petit, 1880, p. 7, Pl. I, figs. 4-6; Wolle, 1887, p. 207, Pl. CXXXII, figs. 6 and 7; P. B.-A., No. 363. Filaments 15-18 μ diam., cells 3-8 diam. long; chromatophore single, quite broad, making 3-8 turns in the cell; fertile cells much swollen, somewhat shortened, 42-48 μ diam.; spores ellipsoid, dark yellow at maturity, 2 diam. long, diam. 30-36 μ. Mass., Conn., N. J. *Europe.*

Resembles *S. tenuissima*, but larger, with broader and more densely twisted spiral.

30. S. SPREEIANA Rabenhorst, Algen, No. 988; Petit, 1880, p. 7, Pl. I, figs. 7-9; Wolle, 1887, p. 208, Pl. CXXXII, figs. 4 and 5; P. B.-A., No. 1019. Filaments 18-21 μ diam., cells 10-25 diam. long; chromatophore single, slender, making 1½-4 turns in the cell; fertile cells swollen, not shortened, 30-42 μ diam.; spores ellipsoid, yellowish at maturity, 2-3 diam. long, diam. up to 36 μ. Mass., Washington, Cal. *Europe.*

The very long cells, with a loose, almost inconspicuous spiral, the swelling in the fertile cells tapering to each end of the cell, sufficiently distinguish this species.

31. S. QUADRATA (Hass.) Petit, 1874, p. 41, Pl. I, fig. 2; 1880, p. 8, Pl. I, fig. 13; Wolle, 1887, p. 208, Pl. CXXXII, figs. 8-10; P. B.-A., No. 366. *S. bifaria* (Bailey) Kützing, 1855a, p. 7, Pl. XXI, fig. 3. Filaments 24-27 μ diam., cells 3-9 diam. long; chromatophore single, broad, making 1½-5 turns in the cell; fertile cell much swollen, up to 54 μ diam., appearing like a rectangle with rounded corners; spores ellipsoid or cylindric-ellipsoid, brown at maturity, 1½-2 diam. long, diam. 42-48 μ. Mass., N. Y., Pa. *Europe.*

Easily recognizable by the peculiar shape of the fertile cells. According to Wolle, *S. pulchella* Wood, 1872, p. 164, Pl. XIV, fig. 2, is a synonym of this species. The plate, though apparently not very characteristic, does not contradict this conclusion. *Zygnema bifaria* Bailey, from examination of authentic specimens, agrees fully with *S. quadrata*.

32. S. WEBERI Kützing, 1843, p. 279; Petit, 1880, p. 9, Pl. I, figs. 10-12; Wolle, 1887, p. 208, Pl. CXXXII, fig. 11; P. B.-A., No. 368. Filaments 22-28 μ diam., cells 6-16 diam. long;

chromatophore single, slender and loose, with large pyrenoids, making 3½-6 turns in the cell; fertile cells not swollen, or only enough to contain the spores, which are ovoid, 1½-2 diam. long, diam. 26-30 μ. Mass., N. Y., N. J., Pa. *Europe.*

From *S. Grevilleana*, which this species considerably resembles, it is distinguished by never having more than one spiral, and by cells little if at all swollen.

33. S. GREVILLEANA (Hass.) Kützing, 1849, p. 438; Petit, 1880, p. 10, Pl. II, figs. 1-5; Wolle, 1887, p. 209, Pl. CXXXII, figs. 12-13; P. B.-A., No. 362. Filaments 28-33 μ diam., cells 3-10 diam. long; chromatophore broad, usually single but occasionally two in scattered cells, making 4-5, sometimes 6-9 turns in the cell; fertile cells much swollen; spores ovoid with rounded ends, yellowish at maturity, 2-2½ diam. long, diam. 30-36 μ. Mass., N. J., Iowa. *Europe.*

Often forming extensive masses, of a bright green color and lubricous. To be distinguished carefully from *S. Weberi*, as noted under that species.

34. S. GROENLANDICA Rosenvinge, 1883, p. 37, Pl. VII. Filaments 18-23 μ diam., cells 18-28 diam. long; chromatophore single, making 3-8 turns in the cell; fertile cells swollen in the middle, the swollen part cylindrical or sub-cylindrical, one-third to one-fourth the total cell length; spores ellipsoid, 34-38 × 100-130 μ, dark brown; conjugation lateral; parthenospores occurring in unswollen cells, the spores elongate, but of more or less irregular form, nearly as large in diam. as the cell. Greenland, Mass.

Resembling somewhat *S. quadrata* and *S. Spreeiana*; from the former it differs by the much longer cells, the swelling occupying only a small part of the whole length; from the latter by the swelling being sharply marked off from the unswollen part of the cell, and also by the color of the spore, dark brown at maturity instead of yellow.

35. S. HASSALLII (Jenner) Petit, 1880, p. 12, Pl. II, figs. 6-8; Wolle, 1887, p. 210, Pl. CXXXIII, figs. 5-7; Phyk. Univ., No. 732. Filaments 30-35 μ diam., cells 4-8 diam. long; chromatophores 2, quite broad and loose, making 1½-2 turns in the cell; fertile cells slightly swollen; spores ellipsoid, 1½-3 diam. long, diam. 42-48 μ, yellow at maturity. Mass., Iowa. *Europe.*

36. S. INSIGNIS (Hass.) Kützing, 1849, p. 438; Petit, 1880, p. 13, Pl. III, figs 1 & 2; Wolle, 1887, p. 210, Pl. CXXXIII,

figs. 8 & 9; Wittr. & Nordst., Alg. Exsicc., Nos. 958, 1373. Filaments 38-45 $\mu$ diam., cells 4-12 diam. long; chromatophores 3, very slender, pale green, with large pyrenoids, making ½-1½ turns in the cell; fertile cells much swollen and shortened; spores ellipsoid, 1½-3 diam. long, diam. up to 48 $\mu$. N. J., Pa. *Europe.*

Our only species with replicate cell walls and three spirals; the typical form quite distinct, but connected with *S. Hassallii* by the following variety.

Var. HANTZSCHII (Rab.) Petit, 1880, p. 13; *S. Hantzschii* Wolle, 1887, p. 211, Pl. CXXXIII, figs. 10-11; P. B.-A., No. 364. Chromatophores usually 2, occasionally 3. Mass., Pa. *Europe.*

Petit notes that in the conjugation in this variety, filaments with two spirals frequently unite with filaments of three spirals; in this case the three spiral cells always function as female, receiving the contents of the two spiral cells and developing the spore.

37. S. PROTECTA Wood, 1872, p. 165, Pl. XIV, fig. 3; *S. elegans* Cleve in Wittrock, 1868, p. 190; *S. calospora* forma *gracilior* Cleve, 1868, p. 26, Pl. VIII, figs. 2 and 3; *S. calospora* Petit, 1880, p. 11, Pl. II, figs. 11-13; Wolle, 1887, p. 209, Pl. CXXXIII, figs. 3 and 4; P. B.-A., No. 360. Filaments 32-36 $\mu$ diam., cells 6-12 diam. long; chromatophore single, slender and loose, making 4-5 turns in the cell; fertile cells little or not at all swollen, not over 42 $\mu$ diam.; spores ellipsoid or cylindric-ellipsoid with rounded ends, yellow at maturity, 2-3 diam. long, diam. 40-42 $\mu$; median membrane punctate. Fig. 8. Mass., Conn., N. J., Mich. *Europe.*

The only species occurring with us which has the replicate cell walls and the punctate membrane. It is a beautiful object under the microscope, the yellow spores with their elegant margin standing out strongly against the dark green filaments. In Cleve's description of *S. calospora* two forms are distinguished; forma a *major*, forma b *gracilior*; afterwards the second form was raised to specific rank as *S. elegans*, but this name cannot stand as there is an earlier *S. elegans* Bonhome, 1858, p. 6. The genuine *S. calospora*, *S. calospora* forma *major* of the original description, appears to be unknown outside of Scandinavia, but *S. protecta* seems common in this country as well as in various parts of Europe. Wittrock considers *S. elegans* to be the same as Vaucher's *Conjugata longata*, but the evidence seems hardly sufficient to justify transferring the name to this species, from the so long recognized *S. longata* Kütz.

Subgenus SIROGONIUM. Cells directly conjugating, without formation of tube.

38. S. STICTICA (Eng. Bot.) Wille, 1884, p. 34; P. B.-A., No. 1366; *Sirogonium sticticum* Petit, 1880, p. 34, Pl. VII, figs. 6-8; Wolle, 1887, p. 222, Pl. CXLI, figs. 8-10. Filaments 38-54 $\mu$ diam., cells 2-4 diam. long; chromatophores 3-4, narrow, parallel and straight or slightly curved; fertile cells shortened but only very slightly swollen; conjugation of cells direct, by genicular bending towards each other of two filaments, the female filament larger than the male; each of the original filament cells dividing into two, rarely three in the male filament; of these cells two, one from each filament, unite to form the spore, the others remaining sterile; spores ellipsoid, yellowish at maturity, 1½ diam. long, up to 60 $\mu$ diam. Florida, Cal.

*So. America, Europe.*

Though this plant has long been kept as a distinct genus, its inclusion in *Spirogyra* seems justified by an intermediate form, *Sirogonium ceylanicum* Wittr. It is amply distinct from any other American species by the combination of characters, linear slightly spiral chromatophores and conjugation without formation of tubes.

Doubtful species of *Spirogyra*.

*S. neglecta* Wolle, 1887, p. 216.

*S. subaequa* Wolle, 1887, p. 217; appears to belong under *S. bellis*.

*S. rivularis* Wolle, 1887, p. 220; the figures in Pl. CXXXVI do not agree with the descriptions of other authors.

*S. adnata* Wolle, 1887, p. 220, Pl. CXXXV, figs. 3 and 4, seems indistinguishable from *S. decimina*.

*S. elongata* Wolle, 1887, p. 221, refers to Pl. CXXXV, figs. 1 and 2, but in the volume of plates these figures are indicated as *S. insignis* var. *elongata*; the dimensions of the figures agree best with *S. elongata*, but under the circumstances it is uncertain just what Wolle's plant was. *S. elongata* Wood, 1872, p. 164, Pl. XIV, fig. 1 is *S. tenuissima* (Hass.) Kütz.

### 3. DEBARYA Wittrock, 1872, p. 35.

Cells cylindrical, about 5 times as long as broad; dissepiments even; chromatophore an axillary plate with several pyrenoids; conjugation between two filaments not differing in appearance; zygospore formed in the tube, with smooth, saccate, yellowish, translucent outer membrane, and browish-yellow median membrane, with three longitudinal parallel ridges, connected by fine, radial cross lines.

D. GLYPTOSPERMA (De Bary) Wittrock, 1872, p. 35; P. B.-A., No. 1419. *Mougeotia glyptosperma* De Bary, 1858, p. 78, Pl. VIII, figs. 20-25; Wolle, 1887, p. 229, Pl. CXLVI, figs. 6-9. Filaments crisped, lubricous, 10-15 μ diam.; cells 6-12 diam. long; fertile cells still longer; spores ovoid, 42-49 × 30-40 μ. Fig. 9. Mass., Minn., Florida. *Europe, New Zealand.*

The peculiarly striate spores, ovoid, set lengthwise of the tube, occupying the whole space between the filaments, distinctly characterize this species.

4. ZYGOGONIUM Kützing, 1843, p. 280.

Cells cylindrical, as long as broad to twice as long; dissepiments even; two axillary, irregular chromatophores, each with one pyrenoid; zygospore formed in the tube between two cells not differing in appearance; the prolongation from each cell cut off from the rest of the cell by a wall, before uniting with the prolongation from the other cell; akinetes sometimes formed, as in *Zygnema*.

The protoplasm that is to take part in the formation of the zygospore gathers at the newly formed tube, and is cut off from the mother cell; then the wall at the end of the tube is dissolved where it touches the tube from the other cell, and the two recently formed small cells unite to form the spore. In *Zygnema* the spore is formed in a tube which still communicates with both the filament cells. This is practically the only difference between the genera, though the chromatophore is less regularly star-shaped in *Zygogonium* than in *Zygnema*.

Z. ERICETORUM Kützing, 1845, p. 224; *Z. Agardhii* Wolle, 1887, p. 226, Pl. CXLV, figs. 6 and 7. Filaments 15-25 μ diam., cells 1-4 diam. long, greenish, becoming brownish, purplish, or blackish by exposure to air and sun; spores globose to ovoid, 20-25 μ diam. Fig. 10.

Var. TERRESTRE Wittr. and Nordst., Alg. Exsicc., No. 1594; P. B.-A., No. 519. Color more uniformly purple or violet; cells somewhat constricted at the nodes; often with short rhizoidal branches; wall thicker and stouter; seldom fruiting. On moist ground. Both type and variety, Maine, Mass., Florida. *Europe, So. America.*

The peculiar mode of producing the zygospores places this species in a separate genus from forms like *Zygnema pectinatum*, which it otherwise much resembles. *Zygnema Ralfsii* Wolle, 1887, p. 227, appears to be a doubtful determination, and the specimens on which it is based might prove to belong to this species. Of *Z. aequale* Wolle says "we assume the name at a hazard"; and of *Z. parvulum* "we quote it without confidence in its value"; these names need hardly be retained. *Z. purpureum* Wolle, 1887, p. 224, is very incompletely described; neither from text or plate can be learned the form of the chromatophores, nor the character of the membrane; dimensions also are uncertain, and until further evidence it must be classed as doubtful.

## Family 2. MESOCARPACEAE.

Cells cylindrical, always several times as long as broad, united in unbranched filaments, rarely having short, rhizoidal branches. Chomatophore an axile plate with several pyrenoids; nucleus at the middle of the plate. Conjugation between either two cells of the same filament or cells of two filaments. Part of the protoplasm separates from the rest in the cell; the part so separating unites with a similar part from the other cell, to form the zygospore, which is either entirely in the tube connecting the cells, or extends somewhat into one or both cells; spore varying in form, but usually lentiform, with round or four- or six-angled outline; outer membrane of spore colored yellow or brown, smooth or variously sculptured. Partheno-spores, akinetes, and aplanospores sometimes occur, much as in the *Zygnemaceae*.

Only two genera of *Mesocarpaceae* are now recognized, *Gonatonema* with two species, and the large genus *Mougeotia*, including the former genera *Mesocarpus*, *Craterospermum*, *Plagiospermum*, *Staurospermum* and *Sphaerospermum*. The distinctions as to shape and surroundings of the spore, on which these genera were founded, have been proved to be uncertain, the types characteristic of the different genera sometimes occurring on the same plant.

### KEY TO THE GENERA OF MESOCARPACEAE.

Aplanospores with double membrane formed in the middle part of a cell, shutting off the remainder of the cell by a wall. Conjugation unknown. 2. GONATONEMA.

Zygospores formed as described for the family; aplanospores exceptional. 1. MOUGEOTIA.

### 1. MOUGEOTIA Agardh, 1824, p. XXVI.

Cells cylindrical, several times as long as broad; dissepiments somewhat lens-shaped; chromatophore an axillary plate with two or more pyrenoids; zygospores formed in the tube, sometimes occupying the whole width of one or both of the original cells, thus bounded by 2, 3, or 4 cells; spore with two membranes, the outer colored, smooth or sculptured; akinetes, when occurring, with single membrane, formed by a division of the mother cell into three parts, of which the middle part becomes the akinete.

KEY TO THE SPECIES OF MOUGEOTIA.

1. Fertile cell bounded by 2 cells. Sect. MESOCARPICAE 2.
1. Fertile cell bounded by 3 cells. Sect. PLAGIOSPERMICAE. 14. *M. tenuis.*
1. Fertile cell bounded normally by 4 cells, exceptionally by 2 or 3. Sect. STAUROSPERMICAE. 13.
2. Conjugation scalariform. 3.
2. Conjugation lateral, rarely scalariform. 12. *M. genuflexa.*
2. Conjugation geniculate. 13. *M. laetevirens.*
3. Spore smooth. 4.
3. Spore pitted or punctate. 11.
4. Filaments 15 μ diam. or less. 3. *M. parvula.*
4. Filaments 20 μ diam. or more. 5.
5. Spore diam. greater than length of tube; spore extending into the cell on each side. 6.
5. Spore occupying the tube only. 9.
6. Spore 60 μ diam. 5. *M. minnesotensis.*
6. Spore 45 μ diam. or less. 7.
7. Filaments 15 μ diam. or less. 7. *M. delicatula.*
7. Filaments 20 μ diam. or more. 8.
8. Filaments straight. 4. *M. sphaerocarpa.*
8. Filaments geniculate. 6. *M. divaricata.*
9. Filaments about 50 μ diam. 10. *M. crassa.*
9. Filaments 30 μ diam. or less. 10.
10. Spores 55-60 μ diam. 11. *M. macrospora.*
10. Spores 30-40 μ diam. 1. *M. scalaris.*
11. Spores transversely ovoid, extending into the filaments. 8. *M. verrucosa.*
11. Spores globose or nearly globose. 12.
12. Filaments 8-10 μ, rarely 15 μ diam. 2. *M. nummuloides.*
12. Filaments 25-32 μ diam. 9. *M. robusta.*
13. Spores punctate. 15. *M. quadrangulata.*
13. Spores smooth. 14.
14. Filaments bluish or purplish with age. 18. *M. capucina.*
14. Filaments not bluish or purplish with age. 15.

15. Filaments 10-12 $\mu$ diam. 19. *M. calcarea.*
15. Filaments 8 $\mu$ or less. 16.
16. Spores quadrangular with concave sides. 16. *M. viridis.*
16. Spores quadrangular with straight sides. 17. *M. elegantula.*

1. M. SCALARIS Hassall, 1842, p. 45; P. B.-A., No. 963; *Mesocarpus scalaris* Wolle, 1887, p. 230, Pl. CXLVII, figs. 2 and 3; *Sphaerocarpus scalaris* Kützing, 1855a, p. 2, Pl. V, fig. 1. Filaments 25-30 $\mu$ diam., rarely 20-23 $\mu$, cells 2-6 diam. long, rarely more; fertile cells somewhat elongate, slightly geniculate; spores 30-38 $\mu$ diam., globose or slightly ovoid, membrane yellowish brown, smooth, occupying the tube between the two straight or very slightly bent cells.* Mass., N. J. *Europe.*

2. M. NUMMULOIDES (Hass.) De Toni, 1889, p. 713; P. B.-A., No. 714; *Mesocarpus nummuloides* De Bary, 1858, p. 80, Pl. VIII, figs. 9 and 10; Wolle, 1887, p. 231, Pl. CXLVIII, figs. 1 and 2. Filaments 8-10 $\mu$, rarely 15 $\mu$ diam., cells 5-12 diam. long; spores globose or broadly ovoid, 17-23 $\mu$ diam., rarely larger, occupying the tube but not extending into the filaments; membrane brown, pitted. Me., Mass., N. J. *Europe.*

3. M. PARVULA Hassall, 1843b, p. 434; *Mesocarpus parvulus* De Bary, 1858, p. 80, Pl. II, fig. 15; Wolle, 1887, p. 230, Pl. CXLVIII, figs. 3 & 4. Filaments 6-10 $\mu$ diam., cells 5-12 diam. long; spores globose, 8-24 $\mu$ diam., occupying the tube and sometimes projecting very slightly into the filaments; membrane brown, smooth.† "Pools, north, south and west." Wolle. *Europe.*

4. M. SPHAEROCARPA Wolle, 1887, p. 227, Pl. CXLVI, figs. 1 and 2; P. B.-A., No. 1173. Filaments 20-25 $\mu$ diam., cells 3-6 diam. long; spores spherical, about 40 $\mu$ diam.,

* *M. recurva* (Hass.) De Toni, 1889, p. 714; *Mesocarpus recurvus* Wolle, 1887, p. 231, Pl. CXLVII, fig. 6, if the plate is correctly drawn, would seem to be a smaller *M. scalaris*, or a larger *M. parvula* Hass., and hardly an autonomous species.

*M. radicans* Wolle, 1887, p. 231, Pl. CXLVIII, figs. 7-10, can hardly be *M. radicans* Kütz., 1855a, p. 1, Pl. III, fig. 1, which has rhizoidal branches smaller than the filaments, while Wolle's figures show branches as large as the filaments and of the same appearance. An examination of an authentic specimen shows the figures to be correct, although the branching is not as abundant as represented. Possibly, as suggested by Wolle, it is an abnormal condition of *M. scalaris.*

† *M. parvula* var. *angusta* (Hass.) Kirchner. Under this name is distributed in Tilden, Amer. Algae, No. 284, a sterile plant, grown in an aquarium under abnormal conditions; it can hardly be considered a certain determination.

smooth, projecting from the tube into the conjugating cells.* N. J., Pa., Florida, Cal.

5. M. MINNESOTENSIS Wolle, 1887, p. 228, Pl. CXLVI, fig. 3. Filaments 15-18 $\mu$ diam., cells 4-5 diam. long; spores spherical, reddish brown, about 60 $\mu$ diam., projecting much into the conjugating cells. Minn.

6. M. DIVARICATA Wolle, 1887, p. 228, Pl. CXLVI, fig. 4. Filaments 20 $\mu$ diam., cells 4-10 diam. long, fertile cells somewhat geniculate; spores about 45 $\mu$ diam., brown, projecting into the conjugating cells. Pa.

7. M. DELICATULA Wolle, 1887, p. 228, Pl. CXLVI, fig. 5. Filaments 12-14 $\mu$ diam., cells 4-6 diam. long; spores spherical, 25-30 $\mu$ diam., projecting slightly into the conjugating cells. Canada.

The four species last named have the character in common of large spores occupying not only the whole length of the tube, but also part of each of the conjugating cells. *M. sphaerocarpa* has been found in California, agreeing well with Wolle's description and figure; the three others are known only by Wolle's descriptions; if his figures are correct, it would seem difficult to place them under species before described, and they differ too much to be consolidated in one species; there seems to be no better way than to copy the descriptions and await developments.

8. M. VERRUCOSA Wolle, 1887, p. 229, Pl. CXLVIII, fig. 5. Filaments 13-14 $\mu$ diam., cells 6-10 diam. long, somewhat geniculate; spores transversely ovoid, projecting into the conjugating cells, about 40 $\times$ 20-25 $\mu$; membrane brown, coarsely granular. Alabama.

An imperfectly known plant, no sterile filaments having been recorded; but the characters seem to make it a distinct species; unless indeed it might be an ill-preserved and inaccurately figured *Debarya glyptosperma*.

9. M. ROBUSTA (De Bary) Wittrock in Wittr. & Nordst., Alg. Exsicc., No. 651; *Mesocarpus robustus* De Bary, 1858, p. 80, Pl. II, fig. 16; Wolle, 1887, p. 231, Pl. CXLVII, fig. 5.

* *M. levis* (Kütz.) Archer, 1867, Pl. VIII, figs. 1-3, is near *M. sphaerocarpa*, but has shorter cells and spores of about the same diameter as the filaments, but considerably longer, and set at right angles to the filaments. There is a somewhat doubtful report of its occurrence in the West Indies.

Filaments 25-32 $\mu$ diam., cells 3-8 diam. long, fertile cells slightly bent; spores globose-ovoid, 40-50 $\mu$ diam., finely punctate, occupying the whole tube, but not projecting into the filaments; membrane reddish-brown. Mass., N. J. *Europe.*

The plant figured by Wolle has spores more nearly globose than the usual European form.

10. M. CRASSA (Wolle) De Toni, 1889, p. 716; *Mesocarpus crassus* Wolle, 1887, p. 230, Pl. CXLVII, fig. 1. Filaments about 50 $\mu$ diam., cells 4-10 diam. long; spores spherical, smooth, about 65 $\mu$ diam., entirely filling the tube, but not extending into the filaments. Florida.

11. M. MACROSPORA (Wolle) De Toni, 1889, p. 716; *Mesocarpus macrosporus* Wolle, 1887, p. 230, Pl. CXLVII, fig. 4; P. B.-A., No. 1368. Filaments about 30 $\mu$ diam., cells 6-10 diam. long; fertile cells distinctly geniculate; spores 55-60 $\mu$ diam., occupying fully the tube, but not projecting into the filaments, spherical, smooth. N. H., Pa.

12. M. GENUFLEXA (Dillw.) Agardh, 1824, p. 83; P. B.-A., No. 312; *Mesocarpus pleurocarpus* De Bary, 1858, p. 81, Pl. III, fig. 14; *Pleurocarpus mirabilis* Wolle, 1887, p. 232, Pl. CXLIX, figs. 8-15. Filaments 25-33 $\mu$ diam., cells 2-5 diam. long, straight or geniculate, in the latter case often uniting with other filaments, but not producing fruit in this way; spores globose or ovoid, smooth, yellowish-brown, usually formed by lateral conjugation, over the dissepiment between the two conjugating cells. N. Y., Mass., Me., N. J. *Europe.*

A common species, forming great expansions in quiet water, pale yellowish or whitish green; when removed from the water the filaments soon tend to break up into the individual cells. Though the species is common almost everywhere, the fruit has been considered rather rare; but when it does occur the whole mass, no matter how extensive, is usually all in fruit at once. The scalariform conjugation is very rare, but has been observed in this country.*

13. M. LAETEVIRENS (A. Br.) Wittrock in Wittr. and Nordst., Alg., Exsicc., No. 58; *Craterospermum laetevirens* De Bary, 1858, p. 81, Pl. III, figs. 1-13; Wolle, 1887, p. 235, Pl.

* *Pleurocarpus columbianus* Wolle, 1887, p. 232, Pl. CXLIX, figs. 6 and 7, is described with filaments considerably larger than in *M. genuflexa*; fruit is unknown; it is probably only a form of the common species. The examination of a specimen from Bethlehem, Pa., marked *Pleurocarpus columbianus* in Wolle's writing, shows filaments from 30 to 35 $\mu$ diam.; but little more than in *M. genuflexa*.

CL, figs. 11 and 12; P. B.-A., No. 1367. Filaments 22-40 $\mu$ diam., cells 3-8 diam. long; conjugation geniculate; spores short cylindrical, with the ends towards the filaments, about 40 $\mu$ long by 45-60 $\mu$ diam.; projecting slightly into the filaments; membrane yellow-brown, smooth. N. H., Mass. *Europe.*

Wolle's notes on localities for this species are somewhat contradictory; after "Frequent in pond near Worcester, Mass." he adds "The only specimens recognized as possibly of this genus were collected, July, 1880, in Green Pond, New Jersey."

14. M. TENUIS (Cleve) Wittrock, 1872, p. 39; *Plagiospermum tenue* Cleve, 1868, p. 35, Pl. X, figs. 6 and 7. Filaments 10-13 $\mu$ diam., cells 8-16 diam. long; one of the conjugating cells dividing into three, the lateral cells remaining sterile while the spore is formed in the central cell, the other conjugating cell being then separated from it by a wall, so that the fertile cell is bounded by three cells, two in the same and one in the other filament. Pa., Florida, N. J. *Europe.*

Wolle describes his plant as var. *minor*, cells 17-18 $\mu$ diam., and refers to Cleve's description as giving measurements 25-30 $\mu$ diam.; evidently an error. As Wolle's plant is larger than Cleve's there is no need for preserving the varietal name.

15. M. QUADRANGULATA Hassall, 1843b, p. 434; *M. quadrata* Wittr. and Nordst., Alg., Exsicc., No. 61; *Staurospermum quadratum* De Bary, 1858, p. 81, Pl. VIII, fig. 11; Wolle, 1887, p. 234, Pl. CL, figs. 6-8. Filaments 8-12 $\mu$ diam., cells 6-12 diam. long, fertile geniculate; spores quadrangular with truncate or incurved angles in front view, i.e. when placed so that the two filaments are in a plane at right angles to the line of vision; elliptic in form in side view; occupying the width of both filaments; membrane uncolored, pitted. Mass., N. J. South Carolina. *Europe.*

16. M. VIRIDIS (Kütz.) Wittrock, 1872, p. 39; Wittr. and Nordst., Alg. Exsicc., No. 1591; *Staurospermum viride* De Bary, 1858. p. 81, Pl. II, figs. 17 and 18; Wolle, 1887, p. 234, Pl. CL, figs. 9 and 10. Filaments 6-8 $\mu$ diam., cells 4-10 diam. long; spores quadrangular, with concave sides; in side view oblong; occupying the width of both filaments, outer membrane colorless, smooth, depressed at the corners. Fig. 10. N. J., Fla. *Europe.*

17. M. ELEGANTULA Wittrock, 1872, p. 40, Pl. III, figs. 5-8; G. S. West, 1905, p. 284. Filaments 4-5 $\mu$ diam., cells 15-30 diam. long; chromatophore occupying the central two thirds of the cell, with 5-8 pyrenoids; conjugating cells genicu-

late; spore 20-24 $\mu$ long and wide, 12-14 $\mu$ thick, in face view cruciform-quadrate, in side view subelliptic with truncate apices; outer membrane smooth, hyaline, in front view with slightly rounded angles, in side view oval. W. I. *Sweden.*

18. M. CAPUCINA (Bory) Agardh, 1824, p. 84; P. B.-A., Nos. 563, 1420; *Staurospermum capucinum* De Bary, 1858, p. 81; Wolle, 1887, p. 234, Pl. CL, figs. 1-5. Filaments 15-20 $\mu$ diam., cells 6-14 diam. long, fertile cells sometimes shortened; spores dark red to ochre color, cruciate to quadrangular with much concaved sides; seen from the edge, linear oblong; occupying the width of both filaments; membrane smooth. Mass., N. J. *Europe.*

Forming masses which except when quite young have a color ranging from bluish to deep violet.

19. M. CALCAREA (Cleve) Wittrock, 1872, p. 40, Pl. II. Filaments 10-14 $\mu$ diam., cells 4-20 diam. long; slightly geniculate in conjugation; spores varying in form, mostly globose or angular-globose, 21-50, usually 30 $\mu$ diam.; membrane brown, smooth. Greenland. *Europe.*

It was in this species that the different modes of spore formation, supposed to distinguish different genera, were first observed occurring on one individual.

### 2. GONATONEMA Wittrock, 1878, p. 9.

Vegetative cells as in *Mougeotia;* conjugation unknown; aplanospore with double membrane formed in the middle of an elongated cell, the portions each side of the spore being shut off by the formation of cross walls.

G. VENTRICOSUM Wittrock, 1878, p. 16, figs. 1-13; Wolle, 1887, p. 233, Pl. CXLIX, figs. 1-5; Wittr. and Nordst., Alg. Exsicc., No. 652; *G. notabile*, P. B.-A., No. 1174. Filaments 5-7 $\mu$ diam., somewhat bent geniculately, cells 6-16 diam. long; spores obliquely elliptic, one side being more convex than the other; seen from the side, elliptic, 22-29 $\times$ 13-16 $\mu$; 12-15 $\mu$ thick, yellowish, smooth. Fig. 11. Pa., Cal. *Europe.*

## Order VOLVOCALES.

Vegetative cells always motile, or readily passing into a motile stage as vegetative cells, solitary or united into disk, spherical, or other shape, but not into filaments. Cells uninucleate; chromatophore usually cup-shaped.

KEY TO THE FAMILIES OF VOLVOCALES.

1. Cells free, never forming colonies. 1. CHLAMYDOMONADACEAE.

1. Cells united in colonies. 2.
  2. Colonies of various form, cells motile when free, sometimes when in colonies. 3. TETRASPORACEAE.
  2. Colonies spherical, ovoid, or disk-shape; cells normally always motile. 2. VOLVOCACEAE.

## Family 1. CHLAMYDOMONADACEAE.

Cells free, globose, ovoid, fusiform, or subcylindrical, rarely attached by gelatinous threads, with 2 or 4 cilia; chromatophore thick, cup-shaped, sometimes more or less split, with or without one or more pyrenoids; asexual reproduction by zoospores, 2-8 formed in a vegetative cell, and similar to it in form and structure, increasing to the normal size after leaving the mother cell; also by akinetes; sexual reproduction by gametes, similar to the zoospores, but usually smaller, sometimes 64 in a cell, in some cases with thick membrane; in some cases the male gametes are smaller than the female; by the copulation a spherical zygote is produced, usually red in color. When germinating it becomes green and produces asexual zoospores, in the same way as do the vegetative cells.

### KEY TO THE GENERA OF CHLAMYDOMONADACEAE.

1. Cells fusiform. 3. CHLOROGONIUM.
1. Cells spherical to ovoid. 2.
  2. Protoplasmic threads passing through the cell wall. 2. HAEMATOCOCCUS.
  2. No protoplasmic threads in cell wall. 1. CHLAMYDOMONAS.

### 1. CHLAMYDOMONAS Ehrenberg, 1833, p. 288.

Cells globose, ovoid, or subcylindrical, with 2-4 cilia issuing from the same point; cell with thin, soft, rather close coating; chromatophore with one or more pyrenoids, and usually a red stigma; asexual reproduction by repeated division, usually succeeded by the loss of cilia, or taking place during a Palmella-stage; sexual reproduction either between similar gametes, or between male and female aplanospores. Fig. 13.

Chlamydomonas forms are undoubtedly common in America, as elsewhere, but little is really known as to their identity with European species, which themselves are by no means all clearly established. De Toni, 1889, gives 6 species with some detail, and 10 "species minus notatae." Wille, 1900, notes that the genus contains about 6 species, but does not name them; 1903, he gives 26 accepted and 23 doubtful species, of which very few coincide with species described by De Toni. Wolle, 1887, mentions as Americau, three species, one of them new. Miss

Snow, 1903, figures three forms found in Lake Erie and describes them all as new species; they appear to be nearly related to three European species, but sufficiently distinct to give them at least a prima facie right to a place here; one other form found in America appears identical with a described European species; these four, with the arctic "red snow" are all that can safely be given here. As it is more than probable that these are only a small portion of the species occurring here, no key is given.

1. C. GRACILIS Snow, 1903, p. 374, Pl. I, fig. I. Cells cylindrical, rarely ovoid or spherical, 10-13 $\mu$ long, 5-6 $\mu$ diam.; color dull green; cilia 2, about 1½ times as long as the cell; stigma a dull red disk, about equidistant from either end; pyrenoid at extreme posterior end. Lake Erie.

Nearly related to *C. angulosa* Dill.

2. C. COMMUNIS Snow, 1903, p. 374, Pl. I, fig. II. Cells ovoid, ellipsoid, or cylindrical, 10-13 $\mu$ long, 6-8 $\mu$ diam.; color light yellowish green; stigma inconspicuous, near anterior end; cilia 2, slightly longer than the cell; pyrenoid near center; division longitudinal. Lake Erie.

Nearly related to *S. Steinii* Gorosch.

3. C. GLOBOSA Snow, 1903, p. 375, Pl. I, fig. III. Cells spherical or slightly ellipsoid, 5-8 $\mu$ diam., cilia 2, slightly longer than the cell; chromatophore much thickened at posterior end; stigma small, inconspicuous; pulsating vacuoles at anterior end; pyrenoid at posterior end. Lake Erie.

Nearly related to *C. Reinhardi* Dang.

4. C. MUCICOLA Schmidle, 1897, p. 17, Pl. II, figs. 4-8; Wille, 1903, p. 136, Pl. IV, fig. 6. Cells ovoid, 6-8 $\mu$ long, 3-4 $\mu$ diam.; cilia 2, longer than the cell; pulsating vacuoles at anterior end; no stigma; pyrenoid near center of cell; division transverse. Mass. *Europe.*

5. C. NIVALIS (Bauer) Wille, 1903, p. 147, Pl. III, figs. 44 and 45, Pl. IV, fig. 25. Cell ovoid, 26-36 $\times$ 14-20 $\mu$, wall thickish, uniform or thickened at the posterior end, more or less distinctly lamellate; chromatophore cup-shaped, with one pyrenoid; usually thoroughly colored by haematochrome; asexual reproduction by division into aplanospores with thick, lamellate, smooth wall; also by Palmella-stage of free, spherical, thick-walled red cells, repeatedly dividing; sexual reproduction imperfectly known, but resulting in a spherical or subspherical zygote, 20-34 $\mu$ diam., with red contents and colorless wall, the

outer surface covered with dome-shaped prominences with hexagonal base. Fig. 13.

The "red snow" of arctic and high mountain regions; usually included in the same genus with *Haematococcus pluvialis*, often in the same species; but Wille, 1903, seems to have determined the proper position. Greenland, Alaska. *Europe.*

2. HAEMATOCOCCUS Agardh, 1828, Pl. XXIV.

Cells similar to those of *Chlamydomonas* but having in the motile stages protoplasmic threads passing through the coating from the central mass to the wall; coating usually quite thick, often different in form from the cell itself; cell with or without red stigma, often deep red in color; asexual reproduction by biciliate zoospores produced few in a cell; probable sexual reproduction by smaller biciliate gametes, produced many in a cell; but actual conjugation has not been observed.

H. PLUVIALIS Flotow, 1844, p. 415, Pl. XXIV, XXV; *H. lacustris*, P. B.-A., No. 114; *Sphaerella lacustris* Hazen, 1899, p. 211. Resting cells spherical, 8-80 $\mu$ diam., deep red, with thick wall; dividing into 4-16 biciliate zoospores, with wide, hyaline coating, through which pass very fine, protoplasmic threads; after a short time these spores come to rest, and divide like the parent cell; this may continue for an indefinite number of generations; or at any time the cells may enter into a long resting stage; under certain circumstances the resting spore may divide into 4-32 small, narrowly cylindrical or fusiform spores, probably gametes. Fig. 14. Me. to Texas and Nebraska, Cal. *Europe.*

Common in shallow, easily dried up pools; forming a dull red coating on the bottom and any contained objects; in the active state the cells are nearly or quite green, with chromatophore covering the cell wall, and several pyrenoids.

3. CHLOROGONIUM Ehrenberg, 1837, p. 172.

Cells spindle-shaped, with two cilia at the forward end; coating very thin; cells with two or more pyrenoids, a red stigma, and many vacuoles. Asexual reproduction by division into 4 or 8 daughter cells; sexual reproduction by zoogametes formed 16 or 32 in a cell, by successive division; copulation taking place between gametes of the same or different sizes, forming a round red zygospore, at whose germination 4 new individuals are produced, at first red, then green. Only one species.

C. EUCHLORUM Ehrenberg, 1837, p. 172; Dangeard, 1888, p. 114, Pl. XI, figs. 5-13. Cells 25-35 $\mu$ long, 8 $\mu$ diam., with thin wall and two cilia. In quiet water, aquaria, etc. *Europe.*

The authority for the occurrence of this species in North America is Wille, Natürlichen Pflanzenfamilien, p. 40.

## Family 2. VOLVOCACEAE.

Motile, biciliate vegetative cells as in *Chlamydomonadaceae*, but united in families of definite form, mostly spherical or ovoid, continuing motile. Asexual reproduction by the formation of daughter cells, similar to the parent; sexual reproduction varying much in the different genera, from union of similar cells, to fully specialized oogonia and antheridia. Fresh water plants.

### KEY TO THE GENERA OF VOLVOCACEAE.

1. Cells arranged in the form of a plate with cilia on one face. 1. GONIUM.
1. Cells arranged in spherical, ellipsoidal, or flattened colonies; cilia not confined to one face. 3.
   2. Colony ellipsoidal or spherical, cells crowded together, conical, reaching toward the center. 2. PANDORINA.
   2. Cells not crowded nor reaching towards the center of the colony. 3.
3. Colony ellipsoidal or flattened, cells uniform in size. 4.
3. Colony spherical or sphaeroidal, or if ellipsoidal, with small vegetative and large gonidial cells. 5.
   4. Colony ellipsoidal or spherical, poles not differentiated. 5. EUDORINA.
   4. Colony flattened, horse-shoe-shape, poles differentiated. 4. PLATYDORINA.
5. Cells not connected by protoplasmic processes; of two sizes, smaller vegetative at one pole and larger gonidial at the other. 3. PLEODORINA.
5. Cells connected by protoplasmic processes, not markedly different. 6. VOLVOX.

### 1. GONIUM Müller, 1773, p. 60.

Colony in form of a quadrangular disk, with rounded angles, composed of 4-16 biciliate cells in a single layer, enclosed in a wide, colorless, gelatinous coating, the cilia all on one side of the disk; cells globose, or polygonal by mutual pressure; membrane thin; chromatophore with one large pyrenoid and red stigma. Asexual reproduction by successive division of individual cells in the colony, also by akinetes; sexual reproduction not observed.

#### KEY TO THE SPECIES OF GONIUM.

1. Colony 4-celled. 1. *G. sociale.*
1. Colony 16-celled. 2. *G. pectorale.*

1. G. SOCIALE (Dujard.) Warming, 1876, p. 82; Oltmanns, 1904, p. 150, fig. 95, 2; *G. tetras* Wittr. and Nordst., Alg. Exsicc., No. 50. Colony 4-celled, 20-48 μ wide, vegetative cells oval, 9-20 × 5-14 μ, often with two indentations in the outer end, cruciately arranged about a central, quadrangular, open space. N. H., Mass. *Europe.*

2. G. PECTORALE Müller, 1773, p. 60; Wolle, 1887, p. 163, Pl. CLI, figs. 15-18; Phyk. Univ., No. 287. Colony 25-90 μ wide, composed of 16 cells, 4 central and 3 at each side; cells 5-15 μ diam.; akinetes spherical, 12-15 μ diam., producing 4 biciliate cells, each of which develops to the normal colony. Fig. 16. Me., Mass., Conn., N. J., Pa., N. Y., Ont., Ill., Cal. *Europe, Asia, Africa.*

In the fully developed 16-cell colony, there is a quadrangular space between the four central cells, and 16 triangular spaces among the surrounding cells; at the four-celled stage of development this species is distinguished from *G. sociale* by having two triangular spaces, while *G. sociale* has a quadrangular central opening.

2. PANDORINA Bory, 1824, p. 600.

Colony globose or subglobose, 8, 16, 32 or 64 cells forming a botryoidal mass, surrounded by a wide, gelatinous coating; cells with close, thin membrane, red stigma, and two cilia; chromatophore with one pyrenoid. Asexual reproduction by continued division of the cells; sexual reproduction by the union of similar biciliate gametes, produced singly in any cell of the colony; by the union of two such gametes, of the same or different size, a zygote is produced, of reddish color, which after a period of rest produces 1-3 large, biciliate red zoospores; these after a period of rest produce new colonies by vegetative division.

P. MORUM (Müll.) Bory, 1824, p. 600; Ehrenberg, 1838, p. 53, Pl. II, fig. 33; Wolle, 1887, p. 161, Pl. CLIII, figs. 1-10; P. B.-A., No. 1175. Colony globose to ellipsoid, up to 220 μ broad, usually of 16 cells, rarely more or less; cells 9-15 μ diam.; zygote with smooth external membrane. Fig. 17. Mass., Wis., Ill., Cal. *Europe, Asia, So. America, New Zealand.*

3. PLEODORINA Shaw, 1894, p. 279.

Colony spherical or ellipsoid, containing biciliate cells arranged in a single layer near the surface of the colony; cells of two kinds, vegetative cells in the anterior part of the colony, gonidial cells in the posterior part; cells unconnected, each with a red stigma, one chromatophore occupying nearly the whole cell, with one to many pyrenoids; gonidial cells developing asexually to form new colonies, by repeated divisions; sexual reproduction unknown.

A genus comprising two species, closely related to *Eudorina*, and until sexual reproduction has been discovered, there must be some question whether it is not a stage in the life history of the older genus.

KEY TO THE SPECIES OF PLEODORINA.

1. Gonidial cells 2-3 times larger than the vegetative cells, of about the same number. 1. *P. californica*.
1. Gonidial cells somewhat larger than the four vegetative cells. 2. *P. illinoisensis*.

1. P. CALIFORNICA Shaw, 1894, p. 279, Pl. XXVII. Colony up to 300 $\mu$ diam., containing 64 or 128 cells, about equally divided between vegetative and gonidial; gonidial cells about 2-3 times larger diameter than vegetative cells. In warm shallow fresh water, Cal., Ind., Ill. *Ceylon*.

2. P. ILLINOISENSIS Kofoid, 1898, p. 274, Pl. XXXVI, XXXVII. Colony $46 \times 38 - 200 \times 175$ $\mu$, containing 32, rarely 16 or 64 cells; vegetative cells always 4; gonidial cells from slightly larger to twice the diam. of the vegetative cells. Fig. 18. In warm shallow water, Ill. *Germany*.

The ellipsoid form of this species, with the 4 vegetative cells at the forward end, distinguishes it from other species of *Volvocaceae*. The colony moves forwards in the direction of the long axis, rotating at the same time about this axis; but the rotation is not uniform in direction, changing frequently, like the screw of a steamer when the engine is reversed; the movement of the colony through the water is not unlike that of the steamer's screw, except that reversing the direction of revolution has no effect on the forward motion, which goes on the same, the end with the vegetative cells being always at the front. Another differentiation is that the red stigmata in the cells are brighter, as the cells are located nearer to the forward end.

4. PLATYDORINA Kofoid, 1899, p. 419.

Colony much flattened, cells in one layer, but alternately pointing in opposite directions; cells differently arranged in the anterior and posterior ends; cells all similar, biciliate, with red stigma, parietal chromatophore and one pyrenoid; asexual reproduction by repeated division of all the cells, each cell thus forming a new colony; sexual reproduction unknown. Only one species.

P. CAUDATA Kofoid, 1899, p. 419, Pl. XXXVIII. Colony of horse-shoe-shape outline, twisted about one-eighth of a turn from right to left; maximum size $165 \times 145 \times 25\ \mu$; posterior end with 3 or 5 prolongations, or tails, from the common sheath; cells 16 or 32, arranged in a marginal row of 10 or 12, and a central area of 6 or 20; oblate sphaeroidal, $15\text{-}20 \times 15\text{-}18\ \mu$. Figs. 19 and 20.

In fresh water, Ill.

The alternating position of the cells, the cilia from one projecting on the opposite side of the colony from the cilia of the next cell, seems to indicate an originally rounded colony, compressed so that the cells from opposite sides have been pushed in between each other. This, with the peculiar twist to the membrane, strongly separates this plant from all hitherto known forms. It is noteworthy that the twist of the plane is in the direction corresponding with the most frequent direction of revolution for the species.

5. EUDORINA Ehrenberg, 1832, p. 78.

Colonies globose or ovoid, usually composed of 16-32-64 cells; cells distributed nearly uniformly through the peripheral portion of the hyaline, gelatinous mass, globose or subglobose, with thin membrane, red stigma, and one or more pyrenoids; externally produced into a hyaline pointed projection with two cilia, projecting from the surface of the colony. Asexual reproduction by successive division of cells, ultimately forming colonies like the parent; sexual reproduction by oogonia and antheridia borne by separate individuals; all the vegetative cells being transformed into antheridia, or into oogonia; 64 fusiform or pyriform antherozoids, with two cilia, formed in each antheridium; ripe oospores brownish, with smooth external membrane, developing into new colonies. Only one species.

E. ELEGANS Ehrenberg, 1832, p. 78, Pl. II, fig. 10; Phyk. Univ., No. 231; *E. stagnale* Wolle, 1887, p. 160, Pl. CLII, figs. 11-23. Colonies 50-200 $\mu$ diam.; usually of 32 cells, arranged in three parallel circles of 8 each, with 4 at each pole; cells 12-24 $\mu$ diam. Fig. 21. In standing water, Pa., Ill., Wash.

*Europe, So. America, New Zealand.*

6. VOLVOX Linnaeus, 1758, p. 320.

Colonies spherical, of from 200-20,000 cells; cells pyriform, united by protoplasmic threads, and closely set near the surface of the sphere, the cilia projecting. A small number of cells, usually 8, are specialized as parthenogonidia, asexually forming new colonies by repeated division. Sexual reproduction by antheridia and oogonia; the former containing 8-256 clavate antherozoids, with red stigma and two cilia; oospores round, with smooth or stellate membrane; new colonies formed by their germination, in the same way as by parthenogonidia.

KEY TO THE SPECIES OF VOLVOX.

1. Colonies over 500 $\mu$ diam., containing several thousand cells.
1. V. globator.

1. Colonies not over 300 $\mu$ diam., of less than 1,000 cells.
2. V. aureus.

1. V. GLOBATOR Linnaeus, 1758, p. 320; Ehrenberg, 1838, p. 68, Pl. IV, fig. 1; Wolle, 1887, p. 158, Pl. CLI, figs. 1-10, CLII, figs. 1-9; P. B.-A, No. 1264. Colonies monoecious and usually proterandrous, 600-800 $\mu$ diam., composed of many cells, 3,000-20,000; vegetative cells 2-3 $\mu$ diam.; parthenogonidia to the number of 8 formed in a colony, about 50 $\mu$ diam.; oogonia 20-40 in a colony, about 50 $\mu$ diam.; oospores brownish, outer membrane covered with stellate projections, inner membrane thick, gelatinous; antheridia seldom over 5 in a colony, globose, 35-40 $\mu$ diam., producing numerous antherozoids, 5-6 $\mu$ long. Fig. 22. Mass., Mich., Ill., Cal. *Japan, Europe.*

One of the most striking of the fresh water algae; the very minute cells are united into spherical colonies, large enough to be visible to the naked eye, and moving by innumerable vibratory cilia, two to each cell. It seems to be generally distributed, and sometimes occurs in quantities in ditches and quiet pools, and is found practically throughout the year.

2. V. AUREUS Ehrenberg, 1832, p. 77; 1838, p. 71, Pl. IV, fig. 2; P. B.-A., No. 1176. Proterogynous; colonies about 200 $\mu$ diam., composed of 600-900 cells; vegetative cells 4-6.5 $\mu$ diam.; oogonia 1-15, 50-60 $\mu$ diam., outer membrane smooth, oospore reddish-brown, 48-60 $\mu$ diam.; antheridia numerous, 15-17 $\mu$ diam., containing 16 closely packed antherozoids, 10-13 $\times$ 3-4 $\mu$. Ill., Mich., Cal. *Europe, Asia.*

A smaller plant than *V. globator*, and amply distinct in every particular. The three classes of reproductive organs, parthenogonidia, oogonia, and antheridia, may occur in separate colonies, or any two, or even all three, may occur in the same colony, but in varying proportions; the antheridia may discharge the antherozoids within the mother colony, or may escape intact, and discharge their contents afterwards. The arrangement for cross fertilization is specially noticeable; the oogonia in a colony ripening before the antheridia can be fertilized only by antherozoids from another colony. It is interesting to observe, here in what was a debatable land between animals and plants, as efficient arrangements for cross-fertilization as we find among flowering plants.

## Family 3. TETRASPORACEAE.

Cells normally imbedded in gelatine, in structure like cells of Chlamydomonas, but usually without cilia; dividing vegetatively; asexual reproduction by cells assuming 2 or 4 cilia, escaping from the gelatine, and after a relatively long free existence, coming to rest, and producing a normal colony directly or after a Palmella stage; sexual reproduction by the division of a cell into several zoogametes, by whose copulation is formed a zygote, germinating at once or after a resting period.

KEY TO THE GENERA OF TETRASPORACEAE.

1. Cells without order in formless gelatine. 1. PALMELLA.
1. Cells and colony with some definite form and arrangement. 2.
  2. Cells radiately arranged in a botryoidal mass. 2. BOTRYOCOCCUS.
  2. Cells not radiately arranged. 3.
3. Each family enclosed in a tough, elastic membrane. 3. INEFFIGIATA.
3. Membrane, if any, soft and delicate. 4.
  4. Cells borne on filamentous, branching stalks. 5.
  4. Cells without definite stalks. 6.
5. Frond soft and loose, gelatine not very conspicuous. 7. PRASINOCLADUS.
5. Frond firm, at first solid, later hollow. 8. COLLINSIELLA.
  6. Mature frond a hollow sac of definite form. 7.
  6. Mature frond an expanded membrane or long filament. 4. TETRASPORA.
7. Sac solitary, pyriform. 5. APIOCYSTIS.
7. Sacs subcylindrical, united at base. 6. PALMODACTYLON.

### 1. PALMELLA Lyngbye, 1819, p. 203.

Cells spherical, with bell-shaped chromatophore and one pyrenoid, with broad, gelatinous, diffluent membrane; asexual reproduction by cell division in all directions, cells separating or joined in small families, forming irregular gelatinous masses; also by akinetes and by ordinary cells developing cilia and becoming motile; sexual reproduction by biciliate gametes.

A genus in which have been included at various times a multitude of forms which had no character in common but that of single cells contained in a general gelatinous mass. Many of these supposed species have been found to be stages of growth of Ulothrix, Chaetophora and other genera; indeed a Palmella-stage is recognized in the development of a large part of the green algae. Only one species can now be considered as a distinct organism in itself.

P. MINIATA Leiblein, 1830, p. 338; Wolle, 1887, p. 193, Pl. CLXII, fig. 10; Chodat, 1894, p. 587, Pl. XXII, figs. 1-15. Cells varying much in size, 3-40 μ diam., colored by haematochrome, orange-, brick-, or blood-red, or yellow, solitary or united 2-8, forming irregular gelatinous masses; membrane thick, hyaline, more or less distinctly lamellate, diffluent; sporangia 10-12 μ diam., each producing 4-8 zoospores; or a single cell developing to a biciliate zoospore-like form; sexual reproduction by gametes similar to the smaller zoospores. In moist places, generally distributed. Fig. 23. *Europe.*

Var. AEQUALIS Nägeli, 1848, p. 67, Pl. IV.D, fig. 2; Wolle, 1887, p. 193, Pl. CLXII, fig. 10; P. B.-A., No. 1314. Cells of nearly uniform size, 12-15 μ diam.; color brick-red, easily changing to green; wall thinner and less distinctly lamellate than in the type. Cal. *Europe.*

2. BOTRYOCOCCUS Kützing, 1849, p. 892.

Cells ovoid-cuneate with rounded ends, radiately arranged in rounded colonies, united in botryoidal masses by a gelatinous coating, free or attached. Chromatophore covering the cell wall, without pyrenoid; asexual reproduction by cells becoming biciliate and motile; they soon come to rest, divide, and take a red color; in these cells gametes are formed, which by conjugation form a spherical zygospore, whose further develop- is unknown.

B. BRAUNII Kützing, 1849, p. 892; Wolle, 1887, p. 195, Pl. CXXIV, figs. 1-4; P. B.-A., Nos. 263, 1177. Family about 1 mm. diam., botryoidal and more or less lobed, at first green, later brownish-red; cells ovoid or irregular, about 6 μ diam. Floating in stagnant fresh water. Fig. 24. Mass., N. J., Cal. *Europe.*

3. INEFFIGIATA W. and G. S. West, 1897, p. 513.

Cells ellipsoid or ovoid, with parietal chromatophore (and pyrenoid?) often colored brick-red, united in spherical or sub-spherical families, the cells superficial; each family surrounded by a tough, elastic membrane, with various irregular folds, lobes, processes and spines, the older membrane often including several generations of families; asexual reproduction by cell division, the families separating as they become too large.

The cells have considerable resemblance to those of *Botryococcus Braunii;* the aggregations are more complex, the outer membrane seems quite distinct from anything found in *Botryococcus*, but until we know more of the life history of the two forms, their distinctness is open to question.

I. NEGLECTA W. and G. S. West, 1897, p. 503; 1903, p. 80, Pl. CCCCXLVII, figs. 1-6. Cells 3-5 × 6-10 μ; families 20-50 μ diam.; aggregations of successive families up to 350 μ. In standing water. Fig. 25. Me., Mass. *Europe.*

4. TETRASPORA Link, 1809, p. 9.

Colony (frond) gelatinous, membranaceous; saccate, tubular or plane; containing globose cells in a single layer, scattered more or less in 2s and 4s, the thick cell wall diffluent into the general membrane. Asexual reproduction by successive division of cells in the plane of the membrane; also by cells becoming ciliate and motile; they later come to rest, lose their cilia, form a gelatinous membrane, and divide by 2s and 4s; also by akinetes. Sexual reproduction by the conjugation of small, biciliate gametes, produced 8 in a cell, the zygospore germinating at once.

A genus in which quite a number of species have been described, some of them not very sharply distinguished. They are all fresh water plants, and are very common in brooks and pools.

KEY TO THE SPECIES OF TETRASPORA.

1. Frond cylindrical at all ages. 1. *T. cylindrica.*
1. Frond cylindrical only when young, if ever. 2.
   2. Frond an irregularly inflated sac. 3. *T. gelatinosa.*
   2. Frond at first tubular, but soon splitting into irregular segments, often much perforate. 2. *T. lubrica.*

1. T. CYLINDRICA (Wahl.) Agardh, 1824, p. 188; Kützing, 1849a, Pl. XXX; Wolle, 1887, p. 190, Pl. CLXV, figs. 7 and 8; P. B.-A., Nos. 908, 1510. Frond attached, up to one meter long, seldom more, up to 2 cm. diam., cylindrical, unbranched,

with stipitate base, and usually somewhat clavate tip; consistency firmer than in other species of the genus; cells 14-17 μ diam., with thick and sharply marked wall, generally showing little of the arrangement in fours. Minn., Montana, Alaska. *Europe.*

The type is easily recognizable by its resemblance in habit and texture to *Enteromorpha intestinalis;* but the following variety is more like other species of the genus.

Var. **extensa** (Tilden) Collins, nov. comb.; *Tetraspora extensa* Tilden, Amer. Algae, No. 48. Fronds very long, according to the author up to 35 meters, narrow, not over 1 cm. wide; or irregularly expanded with a diameter of 5 cm.; gelatinous, bright green; cells spherical, more or less in groups of four, 10-15 μ diam. In sluggishly flowing water, in tanks of State fish hatcheries, St. Paul, Minn.

Much more gelatinous than the type, but apparently not distinct; probably a variety due to local conditions.

2. T. LUBRICA (Roth) Agardh, 1824, p. 188; Wolle, 1887, p. 191, Pl. CLXV, figs. 9-11; P. B.-A., Nos. 63, 861. Frond at first attached, tubular or saccate; soon splitting and forming irregular expansions, often with many rounded openings, sometimes quite net-like; up to 20 cm. long and wide, very gelatinous, usually yellowish in color; cells 7-11 μ diam., generally in fours. Fig. 26. *Europe, So. America, New Zealand.*

Very common in spring, apparently everywhere throughout the Northern United States; the perforated and net-like form is usually known as var. *lacunosa* Chauvin, but really has no characters by which it can be distinguished from the type.

3. T. GELATINOSA (Vauch.) Desvaux, 1818, p. 18; Wolle, 1887, p. 191; Phyk. Univ., No. 693; *Ulva gelatinosa* Vaucher, 1803, p. 244, Pl. XVII, fig. 2. Forming inflated bullate masses, not lacunose; very soft and gelatinous; cells 2.5-13 μ diam., very different sizes being found side by side in the same frond. Me., Mass., N. J., Iowa, Cal. *Europe.*

Generally distributed in quiet water; the fronds are more rounded than in other species, and the lack of uniformity in the size of the cells is marked. But there are intermediate forms between it and *T. lubrica.**

* *T. bullosa*, noted in practically all manuals of fresh water algae, is now pretty well known to be a *Monostroma;* it seems to be not uncommon in Europe, but no American specimens have been seen. The American specimens passing under the name of *T. bullosa* var. *cylindracea* (Hilse)

Forma UNIFORMIS Collins, P. B.-A., No. 1265. Forming rounded, gelatinous masses not over 3 cm. diam.; cells 6-8 μ diam., varying but little in size. Cal.

5. APIOCYSTIS Nägeli in Kützing, 1849, p. 208.

Colony microscopic, vesicular, attached by a stipe-like base, containing more or less numerous cells, scattered or arranged in circles, the thick wall diffluent into the general gelatinous mass of the colony; chromatophore nearly covering the cell wall, with one pyrenoid; cells dividing in all directions. Asexual reproduction by cells becoming biciliate as in *Tetraspora;* sexual reproduction by the union of smaller, biciliate gametes.

A. BRAUNIANA Nägeli, 1848, p. 67, Pl. II.A, fig. 1; Wolle, 1887, p. 202, Pl. CXXIII, figs. 6-10; Wittr. and Nordst., Alg. Exsicc., No. 356. Colony pyriform, pale green, 20-100 μ diam., about twice as long; containing usually 8-32, rarely up to 300 globose cells, 6-8 μ diam. Growing on various algae in ponds and ditches.* Fig. 27. Maine, Mass., Fla.

*Europe, New Zealand.*

6. PALMODACTYLON Nägeli in Kützing, 1849, p. 234.

Colonies microscopic, unattached, in the form of elongate sacs, simple or branched, often radiating from a common center; containing globose, thick-walled cells. Asexual reproduction as in *Palmella.*

P. VARIUM Nägeli, 1848, p. 70, Pl. II.B, fig. 1; Wolle, 1887, p. 189, Pl. CXXIV, figs. 8 and 9. *P. simplex* Nägeli, 1848, p. 70, Pl. II.B, fig. 2; Wolle, 1887, p. 189. Colonies composed of many simple or branched, more or less radiately arranged sacs, up to 50 μ diam. by 280 μ long; cells at first in 4-8 longitudinal series, later crowded and without order, 4-7 μ diam. Fig. 28. Maine. *Europe.*

*P. simplex* appears to be merely a young or undeveloped state. "In stagnant fresh water" according to Wolle, but no definite locality given.

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Rabenhorst, all, as far as seen, appear to be young stages of *T. lubrica* or *T. gelatinosa.* The plants distributed as P. B.-A., No. 64, and in Tilden, Amer. Algae, No. 47, seem to correspond with *T. gelatinosa* forma b. of Rabenhorst, 1868, p. 40.

*T. macrospora* F. L. Harvey, 1892, p. 119, Pl. CXXVI, figs. 1-6, should probably be included under *T. gelatinosa.*

* *A. elongata* F. L. Harvey, 1892, p. 120, Pl. CXXVI, figs. 6-11, from Maine, differs from the type only in the more elongate form of the colony, and the slightly larger cells; but *A. Brauniana* varies enough to include the form and sizes given for *A. elongata.*

7. PRASINOCLADUS Kuckuck, 1894, p. 261.

Plants filamentous, branching above; filaments formed of compartments, those below empty, the terminal containing green cells; cells with band-shaped chromatophore and red stigma. Reproduction by cells becoming 4-ciliate, otherwise unchanged.

P. SUBSALSUS B. M. Davis in P. B.-A., No. 564; *Euglenopsis subsalsa* Davis, 1894, p. 388, Pl. XIX. Filaments moniliform, when mature about 1/4 mm. long, at first simple, then di-tri-chotomously branching; cells oblong, 12-20 × 6-9 μ; chromatophore bright green, usually extending round the cell, with no pyrenoid; compartments of filament about the same size as the cells, separated from each other by 1-4 thin, hyaline cross-walls; cilia at the lower end of the motile cells. Forming a thin coating, velvety or gelatinous, on pebbles, Spartina, etc.; salt marshes and sheltered rock pools. Fig. 29. Mass., Me.

Oltmanns, 1904, p. 136, proposes the family Chlorodendraceae for this and a few other forms, as being perhaps the nearest relatives of the Flagellates among the green algae; but while the resemblance is striking, the line of connection with undoubted members of the Tetrasporaceae is so continuous, from *Prasinocladus subsalsus* through *P. lubricus* Kuckuck, *Ecballocystis pulvinata* Bohlin, *E. japonica* Yendo, and *Collinsiella tuberculata* Setchell and Gardner, that the inclusion of all these forms in the Tetrasporaceae seems justified.

8. COLLINSIELLA Setchell and Gardner, 1903, p. 204.

Frond gelatinous, solid or later hollow, composed of pyriform cells, on dichotomous, gelatinous stalks tapering downward from the cells; all enclosed in the general gelatine. Chromatophore band-shaped, with one large pyrenoid; zoospores (?) formed from the contents of the cells.

C. TUBERCULATA Setchell and Gardner, 1903, p. 204, Pl. XVII, figs. 1-7; P. B.-A., No. 909; *Ecballocystis Willeana* Yendo, 1903, p. 199, Pl. VIII, figs. 1-15. Frond dark green, firmly gelatinous, tuberculate; cells 12-20 × 9-12 μ; cells dividing, one daughter cell remaining in position, the other pushing on, at the end of the tapering stalk; this division many times repeated; lower part of the frond attached to the substratum by filamentous outgrowth from the lower cells. Zoospores (?) 8-16, or sometimes more, in the cells in the middle and upper part of the frond. Forming minute tubercles on stones in pools. Fig. 30.

Vancouver Isl. to Cal.

The description given is made by combining the record of Setchell and Gardner with that of Yendo. The arrangement of the cells on long, dichotomous stalks, together with the firm, solid frond, seem to justify maintaining *Collinsiella* as a genus distinct from *Ecballocystis*. The transformation of vegetative into motile cells has not been observed in the genus, but is to be expected, as in other respects the genus resembles *Prasinocladus*.

## Order PROTOCOCCALES.

Vegetative cells motionless, solitary or in spherical or net-like combinations, rarely filiform. Cells uni-, rarely multi-nucleate; chromatophore usually single, disk- or cup-shaped.

KEY TO THE FAMILIES OF PROTOCOCCALES.

1. Cells free or united in gelatinous colonies. 2.
1. Cells united in regular, net- or disk-shaped colonies, not gelatinous. 5. HYDRODICTYACEAE.
  2. Cells multinucleate, relatively large, irregularly branched. 2. PROTOSIPHONACEAE.
  2. Cells uninucleate, of definite form. 3.
3. Cells spherical, relatively large, with many disk-shaped chromatophores. 3. HALOSPHAERACEAE.
3. Cells of various forms, with single chromatophore. 4.
  4. Cells dividing vegetatively. 4. SCENEDESMACEAE.
  4. Vegetative cell-division rare and abnormal. 1. PROTOCOCCACEAE.

### Family 1. PROTOCOCCACEAE.

Unicellular, spherical or pyriform, rarely irregular; free or attached; asexual reproduction by zoospores or aplanospores; sexual reproduction by zoogametes in some instances; normal cell-division rare and exceptional. Marine or fresh water.

The genus *Protococcus* formerly contained a heterogeneous collection of unicellular plants, which have since been all transferred to widely separated genera, and the genus is now hardly recognized by any good authority. The order and family which derived their names from it still remain in good repute. *P. ovalis* Hansgirg in Foslie, 1890, p. 159, Pl. III, fig. 12, was founded on a form found in tide pools near high water mark in Norway, and the same form has been found in a similar station in Maine. It has ovoid or ellipsoid cells, 8-10 $\times$ 9-12 $\mu$, with thin wall and yellow-green contents, solitary or congregated in a formless mass. Until more is known of its history, it cannot be properly located.

KEY TO THE GENERA OF PROTOCOCCACEAE.

1. Cells attached at base or with basal prolongation. 2.
1. Cells without basal attachment or prolongation. 3.
 2. Fresh water; chromatophore cup-shaped; one pyrenoid. 6. CHARACIUM.
 2. Marine; chromatophore more or less broken; several pyrenoids. 7. CODIOLUM.
3. Endophytic. 4.
3. Not endophytic. 5.
 4. Color more or less deep red. 4. RHODOCHYTRIUM.
 4. Color green. 6.
5. Cell membrane with spines, ridges, or other projections. 2. TROCHISCIA.
5. Cell membrane smooth. 1. CHLOROCOCCUM.
 6. Zoospores and gametes biciliate. 3. CHLOROCHYTRIUM.
 6. Zoospores 4-ciliate; gametes unknown. 5. CHLOROCYSTIS.

1. CHLOROCOCCUM Fries, 1825, p. 356.

Cells spherical with usually thin membrane; chromatophore covering nearly the whole cell wall, with one pyrenoid; asexual reproduction by biciliate zoospores, produced many in a cell.

The species of this genus are found in fresh water, and more especially in wet places on land, often where there are impurities from sewage or other animal matter that would be fatal to most green algae. It is extremely hard to draw a line between *Chlorococcum* and *Gloeocystis* on the one hand and *Zoochlorella* on the other.

KEY TO THE SPECIES OF CHLOROCOCCUM.

1. Endozoic. 3. *C. endozoicum.*
1. Not endozoic. 2.
 2. Forming thin coatings in moist places. 1. *C. humicola.*
 2. Forming gelatinous submerged masses. 2. *C. infusionum.*

1. C. HUMICOLA (Näg.) Rabenhorst, 1868, p. 58; P. B.-A., No. 1066; *Cystococcus humicola* Nägeli, 1848, p. 85, Pl. III.E. Cells varying much in size, 3-25 $\mu$ diam., spherical, solitary or united by 2-4; membrane thin, uniform, hyaline. Fig. 31. Greenland, Mass., R. I. *Europe.*

Forming thin green coatings in moist places, especially under dripping water.

2. C. INFUSIONUM (Schrank) Meneghini, 1846, p. 27, Pl. II, fig. 3; P. B.-A., No. 1119. Cells spherical, 15-45 $\mu$ diam.,

rarely larger; loosely united into light green, gelatinous masses; wall sometimes rather thick, hyaline, more or less distinctly lamellate. Mass. *Europe.*

Forming soft, easily scattered gelatinous masses on submerged objects.

3. C. ENDOZOICUM Collins, P. B.-A., No. 1323. Cells 10-25 $\mu$ diam., spherical, thin-walled. In the mantle of the mussel, *Mytilus edulis*, in tide pools. Me.

*C. natans* Snow, 1903, p. 383, Pl. III, fig. XI, is uncomfortably near *C. infusionum*, none of the characters given in the description being distinctive.

2. TROCHISCIA Kützing, 1845, p. 129.

Cells globose or subglobose, with several parietal chromatophores and one or more pyrenoids, with thick membrane, having various spines, ridges, or other projections; asexual reproduction rarely by cell division, more commonly by aplanospores, formed many in a cell by repeated division, escaping by dissolution of the mother cell wall, with membrane at first smooth, later developing characters of the mother cell.

Some of the species of *Trochiscia* are fresh water plankton algae, some inhabit moist places, especially dripping rocks. Care is sometimes needed to distinguish them from spores of desmids, or from unicellular stages of other algae. The knowledge of the American species is nearly all derived from the observations of Reinsch, 1886, and a careful comparison of his descriptions and figures is likely to leave one in a state of serious doubt as to the validity of some of the species; there are certainly three types; respectively with warty projections, spines, and wavy ridges; it may be that three species, one of each type, would include all our forms.

KEY TO THE SPECIES OF TROCHISCIA.

1. Membrane beset with papillae, spines, or wart-like prominences. 2.
1. Membrane beset with wavy ridges. 5.
   2. Projections warty and irregular. 3.
   2. Projections spine-like. 4.
3. Projections rather distant, bluntish; cells 18-23 $\mu$ diam. 1. *T. granulata.*
3. Projections densely set, acutish; cells 14-17 $\mu$ diam. 2. *T. aspera.*
   4. Spines pyramidal, of unequal length. 3. *T. hirta.*

| | |
|---|---|
| 4. Spines very slender, all about 5 μ long. | 4. *T. aciculifera.* |
| 5. Ridges intersecting, enclosing angular areas. | 5. *T. reticularis.* |
| 5. Ridges parallel or concentric. | 6. |
| 6. Membrane one-sixth cell diam. | 7. *T. obtusa.* |
| 6. Membrane one-third cell diam. | 6. *T. arguta.* |

1. T. GRANULATA (Reinsch) Hansgirg, 1888, p. 128; P. B.-A., No. 761. *Acanthococcus granulatus* Reinsch, 1886, p. 239, Pl. XI, figs. 3, 4, and 7. Cells solitary or united in small families, globose, 18-22 μ diam., membrane one-fifth to one-sixth cell diam., covered with rather distant, bluntish, warty projections. Mass. *Europe, So. America.*

2. T. ASPERA (Reinsch) Hansgirg, 1888, p. 128; *Acanthococcus asper* Reinsch, 1886, p. 239, Pl. XI, fig. 2. Cells solitary, globose, 14-17 μ diam.; membrane one-eighth to one-ninth cell diam., densely covered with somewhat acute, warty projections. Dominica. *Europe.*

3. T. HIRTA (Lagerh.) Hansgirg, 1888, p. 128; *Acanthococcus hirtus* Lagerheim, 1882, p. 78, Pl. III, figs. 38 and 39; Wittr. and Nordst., Alg. Exsicc., No. 446. Cells solitary or united in small families, globose, 22-32 μ diam., membrane one-eighth to one-ninth cell diam., with pyramidal spines of unequal length, one-fourth to one-fifth the cell diam. Fig. 32. Greenland. *Europe.*

4. T. ACICULIFERA (Lagerh.) Hansgirg, 1888, p. 129; *Acanthococcus aciculiferus* Reinsch, 1886, p. 241, Pl. XI, fig. 1. Cells solitary or united in small families, globose, subglobose or ovoid, 15-30 μ diam.; densely coated with very numerous slender spines, up to 5 μ long. Mass. *Europe.*

5. T. RETICULARIS (Reinsch) Hansgirg, 1888, p. 129; P. B.-A., No. 1514; *Acanthococcus reticularis* Reinsch, 1886, p. 241, Pl. XI, figs. 12 and 14; including *T. sporoides* (Reinsch) Hansgirg, *Acanthococcus sporoides* Reinsch, 1886, p. 242, Pl. XII, fig. 24; and *T. Reinschii* Hansgirg, *Acanthococcus sp.*, Reinsch, 1886, p. 242, Pl. XI, fig. 13. Cells solitary or united in 5-8-celled families; globose or subglobose, 15-37 μ diam., membrane one-eighth to one-ninth cell diam., with ridgy or wavy prominences, running in various directions, and intersecting to form 24-70 angular areas. Fig.32. Mass., Ill. *Europe.*

*T. sporoides*, according to description and figures, differs only in not forming families, and in having 60-70 areas formed by the more numerous ridges, while *T. reticularis* has 24-36. *T. Reinschii* shows no difference whatever in the description, and the figure shows only a slight difference in the form of the prominences on the ridges.

6. T. ARGUTA (Reinsch) Hansgirg, 1888, p. 129; *Acanthococcus argutus* Reinsch, 1886, p. 242, Pl. XII, figs. 19 and 23. Cells solitary, globose, 31-43 $\mu$ diam., membrane very thick, up to 1/3 the total cell diam., being 12-15 $\mu$; ridges wavy, parallel, or concentric, the projections subacute. Ill. *Europe.*

7. T. OBTUSA (Reinsch) Hansgirg, 1888, p. 130; *Acanthococcus obtusus* Reinsch, 1886, p. 243, Pl. XII, fig. 21. Cells solitary, globose, 34-37 $\mu$ diam., membrane 1/6 cell diam., with parallel or concentric wavy ridges, waves obtuse. Mass. *Europe.*

### 3. CHLOROCHYTRIUM Cohn, 1874, p. 87.

Cells rounded or irregular, with parietal chromatophore and one or more pyrenoids; asexual reproduction by akinetes, and by biciliate zoospores with red stigma, formed by repeated division, escaping singly or enclosed in a gelatinous mass; sexual reproduction by biciliate gametes similarly formed, leaving the mother cell in a gelatinous mass, within which they copulate, producing a 4-ciliate zygote, which finally penetrates the tissue of the host plant, and there develops to the full size. Marine and fresh water.

KEY TO THE SPECIES OF CHLOROCHYTRIUM.

1. In fresh water plants. 2.
1. In marine plants. 3.
  2. A prolongation of the cell wall remaining where the zygote entered the host. 1. *C. Lemnae.*
  2. Cell entirely enclosed, no prologation to surface of host. 2. *C. Knyanum.*
3. Cells with pointed base. 3. *C. Schmitzii.*
3. Base of cell not pointed. 4.
  4. Cell subhemispherical, base flattened. 4. *C. dermatocolax.*
  4. Cells globose or subglobose. 5. *C. inclusum.*

1. C. LEMNAE Cohn, 1874, p. 87, Pl. II; Klebs, 1881, p. 250, Pl. III, figs. 1-10. Endophytic in *Lemna trisulca;* cells ovoid, ellipsoid or irregular, up to 100 $\mu$ diam.; sexual reproduction by biciliate pyriform gametes, formed many in a cell, escaping by the breaking of the cell wall, enclosed in a gelatinous vesicle, within which they conjugate; the subspherical zygote escaping and continuing active, germinating only when falling on a frond of *Lemna;* here attaching itself by the ciliate end, and pushing a tubular extension in between two epidermis cells of the host, the interior part expanding and the protoplasm passing into it, and developing to the normal form and size;

the entering tube remaining as a cellulose thread with a knob-like expansion at the surface of the host. In autumn the cell may develop to a thick-walled akinete, producing gametes in the spring. Fig. 33. N. H. *Europe.*

2. C. KNYANUM Cohn and Szymanski in Kirchner, 1878, p. 102; Klebs, 1881, p. 255, Pl. III, figs. 11-15; P. B.-A., No. 1518. Cells of varying form but usually more or less elongate, often with a distinct neck-like prolongation; up to 100 μ long; zoospores formed many in a cell, escaping through an opening in the body of the cell, not in the neck-like prolongation, enclosed in gelatinous vesicle, from which they soon escape without copulation; ovoid rather than pyriform, soon coming to rest and penetrating the host plant; thick-walled akinetes as in *C. Lemnae*. Sexual reproduction unknown. In old fronds of *Ceratophyllum*, *Elodea*, *Lemna minor*, *L. gibba*, etc., but never found in *L. trisulca*. Mass. *Europe.*

As P. B.-A., No. 1517 was distributed an endophytic alga in Sphagnum from Wood's Hole, Mass., under the name of *C. Archerianum* Hieronymus, 1887, p. 296. The identification must be considered doubtful, in view of the scanty description given by the author of the species, and of some peculiarities of the Wood's Hole plant, which may make even its generic position uncertain.

3. C. SCHMITZII Rosenvinge, 1893, p. 964, fig. 56. Cells clavate or ovoid, with rounded apex and no papilla, and pointed base; up to 370 μ long by 90 μ diam.; chromatophore occupying the greater part of the cell wall, with two or more pyrenoids. Endophytic in various crustaceous marine algae, *Petrocelis*, *Cruoria*, etc. Greenland to Me., Alaska to Washington. *Northern Europe.*

4. C. DERMATOCOLAX Reinke, 1889, p. 88. Cells about 30×20 μ, seen from above rounded or oval, nearly plane below; external surface convex, subhemispherical or subconical; asexual reproduction by numerous zoospores, 4-6 μ long, escaping by an opening in the end of the papilla formed at the apex of the cell at the time of fructification. In *Chaetopteris plumosa*, *Sphacelaria racemosa*, etc. Greenland. *Northern Europe.*

5. C. INCLUSUM Kjellman, 1883, p. 320, Pl. XXXI, figs. 8-17; P. B.-A., No. 514. Cell globose or subglobose, or irregular by conditions of the host plant; usually 80-100 μ diam., sometimes more than twice that size; wall at first thin, later thickening; chromatophore covering the whole surface, with many pyrenoids; when fruiting a cone-shaped prolongation is

formed, reaching to the surface of the host plant; through this the zoospores escape. In fronds of *Iridaea*, *Sarcophyllis*, etc. Greenland, Alaska to Cal. *Northern Europe.*

4. RHODOCHYTRIUM Lagerheim, 1893, p. 43.

Cell dark red in color, with rhizoidal branching prolongations among the cells of the host plant; developing numerous biciliate gametes which escape through a narrow neck, and unite to form a zygote which penetrates between the epidermis cells of the host, and develops a cell like the original one; the gametes may also develop to such a cell without copulation. Thick walled resting cells also formed, whose development is unknown.

The genus seems intermediate between algae and fungi; whether it possess chlorophyll is not certain; the mycelium-like prolongations appear to draw nourishment from the host. Only one species is known.

R. SPILANTHIDIS Lagerheim, 1893, p. 43, Pl. II. Cell spherical to ovoid, or irregularly rounded, 100-200 $\mu$ diam., with relatively thin wall, communicating with the exterior of the host by a tube, the end of which opens to give passage to the gametes; branching prolongations abundant, diminishing to about 4 $\mu$ in the final divisions; gametes obconic to spherical with two cilia attached to the red anterior end; resting cells 100-200 $\mu$ diam., with thick, stratified wall. In stems and leaves of *Ambrosia artemisiifolia*. Fig. 34. South Carolina.
*So. America.*

5. CHLOROCYSTIS Reinhard, 1885, p. 4.

Cells as in *Chlorochytrium*, but asexual reproduction by 4-ciliate zoospores; no sexual reproduction known.

C. COHNII (Wright) Reinhard, 1885, p. 4, Pl. I; Moore, 1900, p. 100, Pl. X; P. B.-A., Nos. 565, 1121. Cells 16-26 $\mu$ diam., spherical or nearly so, chromatophore bright green, usually somewhat star-shaped and covering only part of the cell wall, but sometimes covering the whole, with one large pyrenoid; zoospores of two sizes, one spherical, 6-7 $\mu$ diam., the other pyriform, 2.5-3.5 $\mu$ diam., both 4-ciliate, escaping through an opening in the cell wall; either kind of spore can germinate, and no conjugation has been observed. Fig. 35. Greenland to Mass. *Europe.*

This species forms dense coatings on *Enteromorpha*, *Schizonema* and other marine plants, often penetrating into the tissue of the host, but apparently never entirely covered by the latter.

6. CHARACIUM A. Braun in Kützing, 1849, p. 208.

Cells with cup-shaped chromatophore and one pyrenoid, from narrowly lanceolate or subcylindrical to broadly ellipsoid or subglobose, often more or less bent, attached by a pointed end or by a stipe-like prolongation to the substratum ; asexual reproduction by biciliate zoospores of two sizes, escaping by a hole or slit in the cell, also by akinetes ; the occurrence of gametes is doubtful.

A genus of many species differing much in size and proportions of the cell, attached to larger fresh water algae or other objects ; common, but easily overlooked. Borzi, 1895 has removed a number of species, forming a new genus, *Characiopsis*, allied to the Confervaceae ; some of the species remaining in *Characium* are imperfectly known, and may, when more fully studied, also require removal.

KEY TO THE SPECIES OF CHARACIUM.

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|---|---|
| 1. Growing on animals. | 2. |
| 1. Not on animals. | 3. |
| 2. Ovoid or broadly ellipsoid. | 8. *C. De Baryanum.* |
| 2. Elongate. | 11. |
| 3. Sessile. | 1. *C. sessile.* |
| 3. With longer or shorter stipe. | 4. |
| 4. Stipe with distinct basal disk. | 11. *C. Pringsheimii.* |
| 4. Stipe without distinct basal disk. | 5. |
| 5. Obtuse. | 6. |
| 5. Acute. | 10. |
| 6. Globose to broadly ellipsoid. | 7. |
| 6. Lanceolate to ellipsoid. | 8. |
| 7. Having a rounded stopper-like body at apex of cell. | 6. *C. obtusum.* |
| 7. Without such body. | 5. *C. heteromorphum.* |
| 8. Narrowly lanceolate to linear. | 4. *C. strictum.* |
| 8. Ellipsoid. | 9. |
| 9. Stipe about 4 $\mu$ long. | 3. *C. Naegelii.* |
| 9. Stipe extremely short. | 2. *C. Sieboldii.* |
| 10. Diam. 15 $\mu$ or more. | 9. *C. acuminatum.* |
| 10. Diam. 8 $\mu$ or less. | 7. *C. ambiguum.* |
| 11. With slender prolonged summit. | 12. *C. gracilipes.* |
| 11. With blunt summit. | 10. *C. cylindricum.* |

1. C. SESSILE Hermann, 1863, p. 26, Pl. VII, fig. 6 ; Wolle, 1887, p. 177, Pl. CLIX, fig. 1. Cells 7-9 $\mu$ diam., at first globose, later developing a small apiculum, but continuing sessile. N. J. *Europe.*

2. C. SIEBOLDII A. Braun in Kützing, 1849, p. 208; 1855, p. 32, Pl. III.A.; G. S. West, 1905, p. 286. Cells 15-25×4-9 μ, erect, straight, when young elongate-ellipsoid or lanceolate, rather obtuse; when adult short ellipsoid or obovoid, obtuse; stipe short, without basal disk. Barbados. *Europe.*

3. C. NAEGELII A. Braun in Nägeli, 1848, p. 86, Pl. III. D.; Wolle, 1887, p. 178, Pl. CLIX, fig. 4; Rabenhorst, Algen, No. 512. Cells 20-42×7-18 μ, erect, straight, at first narrowly lanceolate, later oblong or ellipsoid, always obtuse; stipe slender, about 4 μ long, base not swollen. Mass., Pa., Neb. *Europe.*

4. C. STRICTUM A. Braun, 1855, p. 37, Pl. V. A.; P. B.-A. No. 1371. Cells 23-30×6-7 μ, narrowly lanceolate or linear-oblong, straight, apex obtuse or rounded; stipe very short, slightly swollen at the base. Mass., Cal. *Europe.*

5. C. HETEROMORPHUM (Reinsch) Wolle, 1887, p. 178, Pl. CLIX, fig. 6; *Hydrianum heteromorphum* Reinsch, 1875, p. 80, Pl. XI, fig. 3. Cells 20×8-18 μ, globose to ellipsoid, tapering below into the stipe; zoospores escaping by a wide opening at the summit; cell after escape of the zoospores subcylindrical, about 6 μ diam. Pa. *Europe.*

It may be a question whether the cell continues to live after the emission of the zoospores; Reinsch's brief note does not give sufficient information.

6. C. OBTUSUM A. Braun, 1855, p. 39, Pl. III.E. Cell straight, 22-33 μ long, at first oblong-ellipsoid, later broadly ovoid and about half as broad as long; with a rounded stopper-like body at the apex of the cell; stipe very short, slightly thickened at the base. Mass. *Europe.*

7. C. AMBIGUUM Hermann, 1863, p. 26, Pl. VII, fig. 9; Wolle, 1887, p. 177, Pl. CLIX, fig. 5. Cells 24-32×4-8 μ, erect, obliquely and narrowly lanceolate or ensiform, uniformly attenuate to each end, apex cuspidate, with a sometimes curved apiculum; stipe short, slender, not swollen at the base. Mass., Pa. *Europe.*

8. C. **De Baryanum** (Reinsch) nov. comb.; *Dactylococcus De Baryanus* Reinsch, 1875, p. 78, Pl. XI, fig. 1; 1879a, p. 38, Pl. I, figs. 21-24. Cells oblong to ovoid, 20-25×30-40 μ, with relatively stout stipe, about 15 μ long, swollen at the point of attachment into a small, thick disk. On the minute crustacean, *Cyclops.* Mass., Mich. *Europe.*

Reinsch records observing the development of the mature plant just described from a motile cell about 25 μ diam., with red stigma; also the division of the protoplasm of an adult cell into several daughter cells; apart from this, the development is unknown.

9. C. ACUMINATUM A. Braun in Kützing, 1849, p. 892; *Hydrocytium acuminatum* A. Braun, 1855, p. 26, Pl. II.A. Cells 35-40×15-20 μ, oblong or ovoid, apex shortly acuminate, stipe short, sometimes slightly swollen at the base. Mass. *Europe.*

10. C. CYLINDRICUM Lambert, 1909, p. 65, Pl. 79, figs. 10-13; P. B.-A., No. 1269. Cell 24-430 μ long, 10-20 μ diam., cylindrical with rounded apex; tapering at the base into a short stipe, without basal disk. On the minute crustacean *Branchipus vernalis*. May. Mass.

11. C. PRINGSHEIMII A. Braun, 1855, p. 106; Wolle, 1887, p. 177, Pl. CLIX, fig. 3; Wittr. and Nordst., Alg. Exsicc., No. 153. Cells 20-25×6-10 μ, erect, somewhat oblique, ovoid or lance-ovoid, shortly acuminate, apiculum usually oblique; stipe short, expanding below into a minute, yellowish disk. Mass., Pa. *Europe.*

12. C. GRACILIPES Lambert, 1909, p. 65, Pl. 79, fig. 3-6; P. B.-A., No. 1270. Cell regularly curved, 80-480 μ long, 7-13 μ diam., middle part fusiform, tapering above into a long seta, below into a long filiform stipe, attached to the substratum by very minute rhizoids. On *Branchipus vernalis*. Fig. 36. May. Mass.

7. CODIOLUM A. Braun, 1855, p. 19.

Frond unicellular, ovoid to clavate or sub-cylindric, the cell wall prolonged below into a longer or shorter stipe, attached by a simple or forked expansion; chromatophore covering the cell wall or more or less broken, with several pyrenoids; asexual reproduction by quadriciliate zoospores, many in a cell; also by larger aplanospores (?).

The structural plan of all the species of this genus is identical; a deep green cell with thick wall, prolonged below into a slender, colorless stipe; but the proportions and dimensions vary very much. The colored part, known as the clava, may be broadly oval, up to 120 μ diam.; or it may be almost cylindrical, not over 25 μ diam. The total length varies between 175 and 2700 μ, the shorter forms having the largest diameter of clava, and the longer forms tapering very gradually from the base to the only slightly clavate apex; in these slender forms the clava may occupy from one-tenth to three-fourths of the total length, the clava and stipe may be plainly distinct, or may pass into each other imperceptibly. The plants are mostly gregarious, often growing in abundance over long stretches of shore between tide marks, either alone or in company with other small algae; though comparison of specimens collected at different times and places will show many gradations of form, it is usually found that all the plants of one collecting are uniform in character. Quite a number of species have been described, but it has seemed best here to recognize only three, including others under them as forms.

KEY TO THE SPECIES OF CODIOLUM.

1. Growing among the tissues of other algae. 1. *C. Petrocelidis.*
1. Free. 2.
  2. Clava ovoid, much thicker than the stipe. 2. *C. gregarium.*
  2. Clava narrowly clavate, not much thicker than the stipe. 3. *C. pusillum.*

1. C. PETROCELIDIS Kuckuck, 1894, p. 259, fig. 27. Fronds endophytic, in tissue of *Petrocelis*; clava ovoid or obovoid, $65\text{-}90 \times 20\text{-}30\ \mu$; stipe very slender, usually terminating below in a point. Me. to Mass. *Northern Europe.*

The cells are developed among the vertical filaments of the host, and can be detected only by microscopic examination. The endophytic habit of this species renders the stipe unnecessary, and it has become little more than a rudiment.

2. C. GREGARIUM A. Braun, 1855, p. 20, Pl. I; Farlow, 1881, p. 58; P. B.-A., No. 165. Clava ovoid, $250\text{-}500 \times 65\text{-}100\ \mu$, sharply distinguished from the stipe, which varies from 600-1000 $\mu$ in length, and 20-30 $\mu$ in thickness. Occurs usually in company with *Calothrix*, etc., on rocks and shells, along the New England coast; rarely found unmixed, or forming so large a proportion of the mixture as to be noticeable except in microscopic examination. Fig. 37. Me. to N. Y. *Europe.*

Forma **intermedium** (Foslie) nov. comb.; *C. intermedium* Foslie, 1887, p. 193, Pl. II, figs. 1-12; Wittr. and Nordst., Alg. Exsicc., No. 954. Stipe $170\text{-}250 \times 25\text{-}40\ \mu$; clava $150\text{-}300 \times 55\text{-}110\ \mu$. Me. *Northern Europe.*

An extreme form, with much swollen, sometimes almost spherical clava, and short, stout stipe. It has been found among *Calothrix scopulorum* on islands off Portland harbor, Maine.

3. C. PUSILUM (Lyng.) Kjellman, 1883, p. 318. Fronds long, very slender at base of the stipe, widening slowly to the clava, which is seldom over 60 $\mu$ diam.

Forma TYPICUM Wittr. and Nordst., Alg. Exsicc., No. 457; P. B.-A., No. 1126. Widening uniformly from base of stipe to summit of clava; stipe about twice as long as clava; total length up to 2 mm.; greatest diam. about 60-70 $\mu$.

The typical *C. pusillum* has been found in America only in Eastern Maine, where it forms velvety coatings on rocks about half-tide level, unmixed with any other alga, and forming extensive patches on exposed rocks.

Forma AMERICANUM Wille, in P. B.-A., No. 869. Stipe 5-10 times as long as clava, otherwise like the type. On rocks near high water mark, at Marblehead, Mass., forming a coating unmixed with other plants.

Forma **longipes** (Foslie) nov. comb.; *C. longipes* Foslie, 1881, p. 11, Pl. II, fig. 4; P. B.-A., No. 26. Division between stipe and clava usually marked, the lower part of clava being about double the diam. of the summit of the stipe; stipe 30-60 $\mu$ diam., as long as clava; total length up to 1200 $\mu$, largest diameter 100 $\mu$.

This form is abundant along the coast of Maine, forming a practically unmixed coating on rocks at half tide over considerable stretches. In drying, the individual plants adhere in such a way as to leave the transparent stipes exposed in minute spots, giving the surface a mottled appearance, characteristic and readily recognized, but not easy to describe. Something of the same appearance is found in the other forms of these species, but not to the same extent.

## Family 2. PROTOSIPHONACEAE.

Unicellular, terrestrial, relatively large algae, multinucleate; chromatophore large and net-like; cells often giving out colorless prolongations, developing into normal cells at the end; sexual reproduction by zoogametes, asexual reproduction by zoospores.

Only one genus.

### PROTOSIPHON Klebs, 1896, p. 221.

Frond unicellular, multinucleate, with net-like chromatophore and many pyrenoids; in form spherical, cylindrical, or irregular, with a slender, usually unbranched prolongation, penetrating the moist ground on which it grows; cells dividing vegetatively, the divisions each sending down root-like prolongations. Sexual reproduction by biciliate gametes, formed several to many in a cell, and by conjugation forming a star-shaped zygote, which after a period of rest develops directly to a normal plant. Under certain conditions the gametes do not conjugate, but assume a rounded form, and soon develop to a normal plant. Asexual reproduction by aplanospores formed many in a cell, often colored red with haematochrome; these have a longer or shorter resting period, and either develop directly to normal plants, or produce biciliate gametes, similar to those already described. Only one species.

P. BOTRYOIDES (Kütz.) Klebs, 1896, p. 222, Pl. I, figs. 1-16, P. B.-A., No. 1268; *Botrydium granulatum* Rostafinski and Woronin, 1877, p. 16 in part, Pl. V; Tilden, American Algae, No. 45, in part. Exposed part ½-5 mm. diam., vegetative division usually into 4-16 cells; zoospores $15\text{-}20 \times 5\text{-}8\ \mu$; aplanospores globose, about 40 $\mu$ diam. On moist ground, especially clay. Fig. 38. Conn., Minn., Cal. *Europe.*

This species seems to occur usually in connection with one or both species of *Botrydium*, and was described by Rostafinski and Woronin as a condition of that genus. In Miss Tilden's specimens it is in company with *B. Wallrothii* Kütz.

## Family 3. HALOSPHAERACEAE.

Unicellular, spherical, plankton algae of relatively large size; cell thin-walled, uninucleate, with numerous disk-shaped chromatophores, usually with pyrenoids. Asexual reproduction by obconic zoospores, or by aplanospores. Fresh water and marine.

KEY TO THE GENERA OF HALOSPHAERACEAE.

1. Reproduction by numerous aplanospores. 2. EXCENTROSPHAERA.
1. Reproduction by division into 2, rarely 4 cells. 1. EREMOSPHAERA.

### 1. EREMOSPHAERA De Bary, 1858, p. 56.

Cells solitary, uninucleate, free, large, spherical, with numerous small chromatophores, either parietal or radiating from the center, with 1-4 pyrenoids; cell wall normally thin, but sometimes gelatinizing freely; cells often showing several concentric walls; cells dividing into 2, rarely 4 cells, freed by the breaking up of the mother cell wall; resting cells with thick walls and brick-red contents, ultimately resuming the normal condition. Fresh water. Only one species.

E. VIRIDIS De Bary, 1858, p, 56, Pl. VIII, fig. 26; Wolle, 1887, p. 200, Pl. XCLXVII, fig. 11; P. B.-A., No. 458. Fig. 39.

Characters of the genus; appearing under two forms:

Var. MAJOR Moore, 1901, p. 311, Pl. X, figs. 1 and 2; P. B.-A., No. 1315. Cells 70-150 $\mu$ diam.

Var. MINOR Moore 1901, p. 311, Pl. X, fig. 3. Cells 30-50 $\mu$ diam. Greenland, Me., Mass., Conn. *Europe.*

The unusually large size of this unicellular alga, the perfect spherical form, bright green color, and varied, often quite symmetrical arrangement of the small chromatophores, make it an interesting object. Chodat, 1895, describes forms and modes of propagation which if confirmed would change its position among the green algae, and also identify, as stages of growth, other supposedly distinct forms. The long continued and careful studies by Moore failing to show anything of the kind, the present position seems the best for it.

2. EXCENTROSPHAERA Moore, 1901, p. 322.

Cells uninucleate, solitary, free, large; spherical, ellipsoidal, or sometimes irregular and angular; chromatophores large, angular, more or less radiately arranged, covering the entire wall, each with numerous minute pyrenoids; asexual reproduction by numerous aplanospores, escaping by an opening in the cell wall, and increasing in size until the normal dimensions are reached. Fresh water. Only one species.

E. VIRIDIS Moore, 1901, p. 322, Pl. XII. Cells bright green, 22-55 $\mu$ diam., spores 2-3 $\mu$ diam. Fig. 40. Vt., Mass. *Europe.*

In general appearance resembling small forms of *Eremosphaera* with which it often occurs; very likely the "Centrosphaera-state" of *Eremosphaera* described by Chodat should really be referred to this genus.

Family 4. SCENEDESMACEAE.

Unicellular; cells spherical, or developing into various forms, with bell-shaped chromatophore, solitary, or united by gelatine in more or less regular colonies; asexual reproduction by aplanospores. Fresh water, rarely marine plants.

KEY TO THE GENERA OF SCENEDESMACEAE.

1. Living in the cells of lower animals. 1. ZOOCHLORELLA.
1. Not living in the cells of animals. 2.
  2. Cells contained in an extensive, gelatinous thallus. 3.
  2. No external gelatinous thallus. 5.
3. Sporangia much larger than vegetative cells. 12. HORMOTILA.

3. Sporangia not specialized. 4.
4. Thallus a membrane or mass. 10. SCHIZOCHLAMYS.
4. Thallus a simple or branching filament. 11. ELAKATOTHRIX.
5. Mature cell solitary. 6.
5. Mature cells united in colonies. 12.
6. Mother cell elongate, acicular or fusiform, dividing by oblique walls into daughter cells. 2. RHAPHIDIUM.
6. Daughter cells formed in the interior of the mother cell. 7.
7. Cells angular, often with much developed projections. 8.
7. Cells rounded. 10.
8. Cells with distinct polyedral central mass. 7. TETRAEDRON.
8. Cells of rays from a common center, without distinct central mass. 9.
9. Rays unbranched. 9. CERASTERIAS.
9. Rays di-trichotomously divided. 8. THAMNIASTRUM.
10. Cells with spines. 5. CHODATELLA.
10. Cells without spines. 11.
11. Cells ovoid. 4. OOCYSTIS.
11. Cells reniform. 6. NEPHROCYTIUM.
11. Cells spherical. 3. PALMELLOCOCCUS.
12. Cells elongate, side by side in a single or double series. 13. SCENEDESMUS.
12. Cells arranged symmetrically about a center. 13.
13. Cells arranged in one plane. 14. CRUCIGENIA.
13. Cells radiating in all directions. 14.
14. Cells lunate or sickle-shaped. 19.
14. Cells not lunate or sickle-shaped; united to the centre by gelatinous strands or stipes. 15.
15. Stipes short, unbranched. 16.
15. Stipes branched. 17.
16. Cells with spinous projections. 18. SORASTRUM.
16. Cells without spinous projections. 17. COELASTRUM.
17. Cells in series on gelatinous strands. 21. DICTYOCYSTIS.
17. Cells at the ends of gelatinous strands. 18.
18. Cells spherical. 19. DICTYOSPHAERIUM.
18. Cells reniform, ovoid or cordate. 20. DIMORPHOCOCCUS.
19. Cells united by the convex sides. 15. SELENASTRUM.
19. Cells in no definite order in a common gelatinous envelop. 16. KIRCHNERIELLA.

### 1. ZOOCHLORELLA Brandt, 1882, p. 140.

Cells free, minute; spherical, ellipsoid or flattened, with chromatophore covering part of the cell wall, apparently without pyrenoid; asexual reproduction by aplanospores formed by successive division in a cell, freed by rupture of the wall.

The two species noted below live in various lower fresh water animals; they are so intimately associated with the hosts that they were long supposed to be integral parts of the same; in many cases the alga cell divides at the same time as the host cell. Beyerinck, 1890, has proposed a genus *Chlorella*, including these species and some free species, which latter he thinks have been included under *Chlorococcum*; it is difficult to see why *Zoochlorella* should be superseded, unless the ground is that it was described by a zoologist, and not by a botanist.

KEY TO THE SPECIES OF ZOOCHLORELLA.

| | |
|---|---|
| 1. Cells 3-6 μ diam. | 1. *Z. conductrix*. |
| 1. Cells 1.5-3 μ diam. | 2. *Z. parasitica*. |

1. Z. CONDUCTRIX Brandt, 1882, p. 140. Endozoic; cells 3-6 μ diam., in tissues of *Hydra* and allied fresh water organisms. Fig. 41. Mass. *Europe*.

2. Z. PARASITICA Brandt, 1882, p. 140; P. B.-A., No. 1515. Endozoic; cells 1.5-3 μ diam.; in tissues of *Spongilla*, *Ophrydium* and other fresh water organisms. Mass. *Europe*.

2. RHAPHIDIUM Kützing, 1845, p. 144.

Cells elongate, acicular or fusiform, straight or variously curved, with pointed or rounded ends; chromatophore nearly covering the cell wall, usually without pyrenoid; cell dividing by oblique cross walls into 2-32 daughter cells, which separate soon after attaining their full shape and size; less frequently remaining attached in bundles, or to the wall of the mother cell. Widely distributed fresh water plankton algae.

KEY TO THE SPECIES OF RHAPHIDIUM.

| | |
|---|---|
| 1. With a long seta at each end. | 4. *R. setigerum*. |
| 1. Without setae. | 2. |
| 2. Cells 12-25 diam. long, ends very acute. | 1. *R. falcatum*. |
| 2. Cells 3-12 diam. long, ends obtuse or apiculate. | 3. |
| 3. Cells variously twisted and curved. | 2. *R. convolutum*. |
| 3. Cells straight or nearly so, relatively stout. | 3. *R. Braunii*. |

1. R. FALCATUM (Corda) Cooke, 1882, p. 19, Pl. VIII, fig. 4; *R. polymorphum* Wolle 1887, p. 197; P. B.-A., No. 1179. Cells bright or yellowish green, slender, fusiform, at the middle sometimes swollen, sometimes constricted; ends very acute; straight or variously curved; 1.5-3.5 μ diam., 15-25 diam. long, up to 90 μ; usually united 2-32 in a bundle. Greenland to Fla. and westward, Porto Rico. *Europe*.

A common and variable species; *Micrasterias falcatus* is the first name used for any of the forms now included in this species, and must be considered as the type; other forms found with us are as follows: —

Var. ACICULARE (A. Br.) Hansgirg, 1886, p. 118; *R. polymorphum* var. *aciculare* Wolle, 1887, p. 197, Pl. CLX, figs. 22 and 23; *R. aciculare* Wittr., Nordst. and Lagerh., Alg. Exsicc., No. 1243. Very slender, 1.5-3 μ diam., 15-20 diam. long, acicular, straight or slightly curved, usually solitary. Mass., Pa., Neb. *Europe.*

Var. FUSIFORME (Corda) Hansgirg, 1886, p. 119; *R. fasciculatum* Nägeli, 1848, p. 82, Pl. IV.C, fig. 1; P. B.-A., No. 1512. Fusiform, gradually tapering to each end; diam. 2-6 μ, cells 12-20 diam. long, straight or more or less curved, fasciculately clustered. Fig. 42. Mass., Pa. *Europe.*

2. R. CONVOLUTUM (Corda) Rabenhorst, 1868, p. 46; Wolle, 1887, p. 198, Pl. CLX, figs. 1-5. Cells variously curved, convolute or contorted, 3.5-5 μ diam., 3-12 diam. long, ends obtuse or apiculate; cells usually solitary. Me., Mass., Pa., Neb. *Europe.*

3. R. BRAUNII Nägeli in Kützing, 1849, p. 891; Wolle, 1887, p. 198, Pl. CLX, figs. 26 and 27; Wittr., Nordst. and Lagerh., Alg. Exsicc., No. 1245. Cells cyclindric-fusiform, relatively short and stout, 5-8 μ diam., 4-6 diam. long, straight or somewhat curved, slightly tapering at both ends, subobtuse; solitary or in pairs, rarely 3 or 4 together. Mass., Pa. *Europe.*

4. R. SETIGERUM (Schröder) W. and G. S. West, 1901, p. 122. *Reinschiella ? setigera* Schröder, 1897, p. 489. Cells fusiform, the apices attenuate into long, fine setae. Diam. 3-6 μ; length 60-85 μ; chromatophore with one pyrenoid. Mass. *Europe.*

R. FRACTUM W. and G. S. West, 1899, p. 279, from Dominica, is described as near to *R. Braunii*, but somewhat narrower; the special character given is the division of the chromatophore into four subequal parts. As the description was made from dried specimens, it is not impossible that this appearance is due to the preparation for cell division, in which case the distinction from *R. Braunii* would not be clear.

### 3. PALMELLOCOCCUS Chodat, 1894, p. 429.

Cells free, globose, with wall of two or more layers, with one or more disk-shaped chromatophores without pyrenoid, often concealed by an orange-red coloring; asexual reproduction by bipartition of the cell, also by division into numerous aplanospores, which escape in a gelatinous vesicle.

KEY TO THE SPECIES OF PALMELLOCOCCUS.

1. Chromatophores several, no coloring matter present. 3. *P. thermalis.*
1. Chromatophore single, usually concealed by reddish coloring matter. 2.
   2. Cells 3-15 $\mu$ diam.; plant of greenhouses, etc. 1. *P. miniatus.*
   2. Cells 10-40 $\mu$ diam.; plant of salt marshes. 2. *P. marinus.*

1. P. MINIATUS (Leiblein) Chodat, 1894, p. 429, Pl. XXV, figs. 11-26; 1902, p. 183, fig. 80; Phyk. Univ., No. 689; *Protococcus viridis* var. *miniatus* Wolle, 1887, p. 181, Pl. CLXII, fig. 5. Cells 3-15 $\mu$ diam., orange red, with more or less oil; forming a gelatinous coating on walls of greenhouses, etc. Fig. 43. Very generally distributed.

2. P. MARINUS Collins, 1907, p. 198; P. B.-A., No. 1316.* Cells 10-40 $\mu$ diam., including wall about 2 $\mu$ thick; color from deep orange to green; aplanospores 8-64 in a cell, spore wall quite thick while still in the mother cell; mass of spores retaining the spherical form long after the disappearance of the mother cell wall. Among various algae in salt marsh pools. Maine.

3. P. THERMALIS G. S. West, 1904, p. 287, Pl. CCCCLXIV, fig. 21. Cells 2-6 $\mu$ diam., deep green, membrane thin and firm; chromatophores 2 or 3, parietal disks; aplanospores 4-16 in a cell. In hot springs. Dominica.

## 4. OOCYSTIS Nägeli in A. Braun, 1855, p. 94.

Cells ovoid; chromatophores single or small parietal disks or grains, with or without pyrenoid; asexual reproduction by division of the contents into 2-8 daughter cells, in the expanded membrane of the mother cell, sometimes a third generation formed before the mother cell wall breaks up.

Quite a number of species have been described in this genus, four of which have been reported in America; it is likely that others will be found. Only numbers 3 and 4 can be considered as safely identified with the European forms of the same names.

KEY TO THE SPECIES OF OOCYSTIS.

1. Cells with a tubercular thickening at each end. 3. *O. solitaria.*
1. Cells without tubercular thickening. 2.
   2. Chromatophores several in a cell. 4. *O. crassa.*

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*By mistake the combination *Pleurococcus marinus* was used in the description in Rhodora; the following text indicates that *Palmellococcus* is meant; the proper form is used in P. B.-A, No. 1316.

2. Chromatophore entire or halved. 3.
3. Ends rounded. 1. *O. Borgei.*
3. Ends acute or subacute. 2. *O. lacustris.*

1. O. BORGEI Snow, 1903, Pl. II, fig. 7. Cells ellipsoidal or slightly fusiform, ends rounded, wall uniform or slightly thickened at one end, with no projection, 9-13 $\mu$ long; chromatophore single, with pyrenoid; cells in colonies of two or a multiple of two, free or united in a common gelatine. In plankton, Lake Erie. *Sweden.*

2. O. LACUSTRIS Chodat, 1897, p. 296; 1902, p. 190, fig. 103. Cells broadly fusiform, with membrane somewhat thickened at the subacute ends, chromatophore single or in distinct halves, without pyrenoid; mother cell wall persistent, retaining the characteristic form. In plankton, Lake Erie. *Europe.*

3. O. SOLITARIA Wittrock in Wittr. and Nordst., Alg. Exsicc., No. 244; P. B.-A., No. 1178. Cells generally solitary, occasionally 2-4 together, ellipsoid, $13\text{-}35 \times 7\text{-}18\ \mu$, with several chromatophores; membrane thickish with a tubercular projection at each end. Fig. 44. Greenland, Me., Mass., Conn., Cal., West Indies. *Europe, So. America.*

Forma MAJOR Wille, 1879, p. 26. Cells about $40 \times 22\ \mu$; often in 4-celled colonies, $60 \times 50\ \mu$. Alaska. *Northern Europe.*

4. O. CRASSA Wittrock in Wittr. and Nordst., Alg. Exsicc., No. 355. Cells usually in twos, ellipsoid to fusiform, $14\text{-}23 \times 10\text{-}18\ \mu$, with several chromatophores; membrane thin, only slightly thickened at the ends. Me., Mass. *Europe.*

5. CHODATELLA Lemmermann, 1898, p. 309.

Cells ovoid or ellipsoid, the membrane bearing two to many setae not thickened at the base; chromatophores one or many, parietal, with or without pyrenoid; cells free or contained in the mother cell wall. Reproduction as in *Oocystis.*

This genus differs from *Oocystis* only by the presence of the setae. Several European species have been described and may be expected here; the following species, the only one yet reported here, is known only from Lake Erie.

C. CITRIFORMIS Snow, 1903, p. 381, Pl. II, fig. VIII. Cells ellipsoidal with an obtuse projection at either end, $13\text{-}23 \times 8\text{-}20\ \mu$; chromatophore single, with pyrenoid; setae slender, in whorls about the projections at the ends of the cells. Fig. 45. Lake Erie.

6. NEPHROCYTIUM Nägeli, 1848, p. 79.

Cells somewhat curved, ovoid or reniform; asexual reproduction by the division of the contents of a cell into 2-16 similar daughter cells, which remain enclosed for a longer or shorter time in the persistent mother cell wall; chromatophore covering nearly the whole surface of the cell, with one pyrenoid.

KEY TO THE SPECIES OF NEPHROCYTIUM.

1. Daughter cells 2-7 μ diam., 3-6 diam. long. 1. *N. Agardhianum.*
1. Daughter cells 11-22 μ diam., 2 diam. long. 2. *N. Naegelii.*

1. N. AGARDHIANUM Nägeli, 1848, p. 79, Pl. III.C; Wolle, 1887, p. 197, Pl. CLXIII, figs. 12-15, 17; Wittr. and Nordst., Alg. Exsicc., No. 528. Daughter cells 2-7 μ diam., 3-6 diam. long; usually 2-4-8 together, somewhat spirally arranged within the mother cell wall which may reach a length of 60 μ. Fig. 46. Me., Mass. *Europe.*

2. N. NAEGELII Grunow in Rabenhorst, 1868, p. 62; Wolle, 1887, p. 197. Daughter cells 11-22 μ diam., about 2 diam long; usually 16 together, irregularly arranged within the mother cell wall. Me. *Europe.*

7. TETRAEDRON Kützing, 1845, p. 129.

Cells solitary, free, with parietal chromatophore occupying the whole or nearly the whole of the cell wall, with one pyrenoid; of very various form, either polyhedric with 4-many angles, or flattened, 3-many angled, and in side view more or less elliptic; angles from obtuse and rounded to very much prolonged and often branched, sometimes repeatedly and finely divided; asexual reproduction by aplanospores, formed 3-many in a cell, developing into the typical form of the mature plant either before or after escape from the mother cell.

A genus containing species differing greatly in form, some of them very much like stages in the development of other algae; *Hydrodictyon* and *Pediastrum*, for instance, produce "polyhedric" resting spores, and it is probable that some such forms have been described as species of *Tetraedron*. Whether forms here included will some time have to be removed for such reason can be decided only by future investigations. It now seems probable that some *Tetraedron* species, at least, are autonomous forms, not forming part of the life cycle of any other plant. *Polyedrium* Nägeli, is a better known name for this genus than *Tetraedron* Kützing, and more appropriate; but the latter has a priority of four years.

KEY TO THE SPECIES OF TETRAEDRON.

1. Cells flattened, 3 or more sided. 2.
1. Cells polyhedric, but often quite irregular. 10.

2. Angles entire and unarmed. 3.
2. Angles spinous or forked. 6.
3. Membrane finely granulate-punctate. 5. *T. punctulatum.*
3. Membrane with a network of ridges. 6. *T. reticulatum.*
3. Membrane smooth. 4.
4. Cells triangular. 2. *T. muticum.*
4. Cells quadrangular. 5.
5. Cells 15-21 $\mu$ diam. 3. *T. tetragonum.*
5. Cells 6-11 $\mu$ diam. 4. *T. minimum.*
6. Angles prolonged into many fine divisions. 8. *T. gracile.*
6. Angles mucronate or spinous only. 7.
7. Angles mucronate. 1. *T. trigonum.*
7. Angles spinous. 8.
8. Quadrate. 9.
8. Polygonal. 10. *T. angulosum.*
9. Regularly quadrate, with short spines. 7. *T. quadratum.*
9. Irregularly 3- or 4-sided, with long spines. 9. *T. quadricuspidatum.*
10. Angles unarmed and undivided. 11.
10. Angles spinous or prolonged and divided. 12.
11. Cells 17-26 $\mu$ diam. 11. *T. pachydermum.*
11. Cells 65 $\mu$ or more in greatest diam. 13. *T. gigas.*
12. Angles spinous but not lobed. 13.
12. Angles lobed or divided. 14.
13. Membrane thick, lamellate; sides plane or slightly concave; one stout spine at each angle. 12. *T. regulare.*
13. Membrane thin; sides convex, unequal; 1 or 2 spines at each angle. 14. *T. armatum.*
14. Angles forked with rounded sinus and two sharp teeth. 15. *T. bifurcatum.*
14. Angles several times lobed or forked. 16. *T. enorme.*

1. T. TRIGONUM (Näg.) Hansgirg, 1888, p. 130; *Polyedrium trigonum* Nägeli, 1848, p. 84, Pl. IV. B, fig. 1; Reinsch, 1888, p. 497, Pl. IV, fig. 1. Cells triangular, 12-37 $\mu$ diam.; thickness 6-16 $\mu$; sides slightly sinuate, angles rounded, mucronate. Fig. 47. Mass., Ill., Pa., Neb., Porto Rico. *Europe, Asia.*

Reinsch gives four forms of this species, distinguished only by dimensions; the American plant comes under forma *majus* Brügger, with diam. of 36 $\mu$.

Var. PUNCTATUM (Kirchner), Hansgirg, 1888, p. 130; *Polyedrium trigonum* var. *punctatum* Kirchner, 1878, p. 104; Wolle, 1887, p. 184. Membrane granulate, mucro small, papilla-like. N. J., Pa., Neb. *Europe.*

2. T. MUTICUM (A. Br.) Hansgirg, 1888, p. 131; *Polyedrium muticum* A. Braun, 1855, p. 94; Reinsch, 1888, p. 498, Pl. IV, figs. 2, 4 and 6. Cells triangular, 13-28 $\mu$ diam., 7-10 $\mu$ thick; sides slightly sinuate, angles rounded, unarmed. Mass., Ill., Pa. *Europe, Australia.*

The Mass. plant comes under forma *majus* Reinsch; sides slightly convex, angles rounded; 23-28 $\mu$ diam., 10-11 $\mu$ thick; the Ill. plant under forma *punctulatum* Reinsch; sides slightly concave, membrane finely punctate, diam. 18-21 $\mu$.

In general form and dimensions this species is much like *T. trigonum*, but has more rounded angles and lacks the spine or mucro characteristic of *T. trigonum*.

3. T. TETRAGONUM (Näg.) Hansgirg, 1889, p. 18; *Polyedrium tetragonum* Nägeli, 1848, p. 84, Pl. IV.B, fig. 2; Reinsch, 1888, p. 499, Pl. IV, fig. 10 a and b; *P. trigonum* var. *tetragonum* Wolle, 1887, p. 184, Pl. CLIX, figs. 7-10. Cells quadrangular, sides slightly sinuate, angles rounded. Diam. 15-21 $\mu$. Mass., Ill., Pa., Neb. *Europe, Australia, So. America.*

Characterized by the squarish outline, with rounded angles and slightly concave sides, with no projections of any kind; it varies slightly as to dimensions, but not otherwise.

4. T. MINIMUM (A. Br.) Hansgirg, 1888, p. 131; Wittr. and Nordst., Alg. Exsicc., No. 1573; *Polyedrium minimum* A. Braun, 1855, p. 94; Reinsch, 1888, p. 499, Pl. IV, fig. 2; Wolle, 1887, p. 185, Pl. CLIX, figs. 28-34. Cells quadrangular, 6-11 $\mu$ diam., sides rather deeply emarginate, angles rounded; in side view elliptic, 3-6 $\mu$ thick. Me., Pa. *Europe, Asia, So. America.*

Resembles a small *T. tetragonum*, but according to Reinsch, is not connected by intermediate forms.

5. T. PUNCTULATUM (Reinsch) Hansgirg, 1889, p. 18; *Polyedrium punctulatum* Reinsch, 1888, p. 500, Pl. IV, fig. 8. Cells quadrangular, 18-21$\times$21-30 $\mu$; in side view rhomboidal, 15-18 $\mu$ at the thickest; sides straight or slightly and irregularly repand, angles obtuse; membrane thin, not lamellate, finely granular-punctate. Mass. *Europe.*

Our plant is forma *rectangulare* Reinsch, with cells longer than wide.

6. T. RETICULATUM (Reinsch) Hansgirg, 1889, p. 18; *Polyedrium reticulatum* Reinsch, 1888, p. 498, Pl. IV, fig. 3. Cells triangular, 26-30 $\mu$ diam.; with equal and nearly straight sides,

angles somewhat rounded; membrane thin, covered with a network of very delicate ridges. Cuba. *Europe, Africa.*

7. T. QUADRATUM (Reinsch) Hansgirg, 1889, p. 18; *Polyedrium quadratum* Reinsch, 1888, p. 499, Pl. IV, fig. 7. Cells regularly quadrate, sides straight or slightly convex, angles obtuse, each with a single spine; membrane rather thick, distinctly of two layers; diam. 17-34 μ; membrane 2-4.5 μ thick.

The type occurs in Europe; we have only forma *minus acutum;* cell 17-18 μ diam.; angles subacute; membrane only indistinctly lamellate. Ill.

8. T. GRACILE (Reinsch) Hansgirg, 1889, p. 19; *Polyedrium gracile* Reinsch, 1888, p. 502, Pl. VII, fig. 1. Cells four-angled, sides equal, emarginate or deeply and obtusely incised, angles prolonged, three times forked, divisions divergent, ultimate divisions very slender, acute; prolongations from the angles as long as the diam. of the cell; cell in side view narrowly elliptic, with prolonged ends; total diam. of cell 35-46 μ; distance between centers of sides 18-20 μ. Mass.

Var. **tenue** (Reinsch) nov. comb.; *Polyedrium gracile* var. *tenue* Reinsch, 1888, p. 502, Pl. VII, fig. 1a. Sides very deeply incised, lobes of the angles in all orders very slender. Mass.

9. T. QUADRICUSPIDATUM (Reinsch) Hansgirg, 1889, p. 18; *Polyedrium quadricuspidatum* Reinsch, 1888, p. 500, Pl. VI, fig. 2. Cells 50-95×36-63 μ, with 3 or 4 unequal sides, convex or concave, each angle ending in a long, acute, stout spine, 13-14 μ long; membrane thin, thickened at the angles; cells in side view narrowly elliptic, with attenuate, spinous ends. Mass. *Europe.*

Quite irregular in outline of the cell, but characterized by the four stout spines; in Mass. is reported the type, also forma *inaequale* Reinsch, which seems to differ only in having spines of unequal length.

10. T. **angulosum** (Larsen) nov. comb.; *Polyedrium angulosum* Larsen, 1904, p. 104, fig. 8. Cells more or less irregularly polygonal, with rounded angles, each with two short spines. Greenland.

Possibly identical with *Polyedrium irregulare* Reinsch, 1888, p. 508, Pl. VII, fig. 3.

11. T. PACHYDERMUM (Reinsch) De Toni, 1889, p. 603; *Polyedrium pachydermum* Reinsch, 1888, p. 504, Pl. V, fig. 2. Cells 6-8-angled, 17-26 μ diam., sides usually equal and symmetrical, emarginate, angles rounded, obtuse; in side view

elliptic; membrane very thick, up to 5 μ, of 2-many lamellae. Mass. *Europe.*

The type is not reported with us, but only forma *minus* and forma *leptodermum*; both forms have cells 17-19 μ diam., membrane thinner and less lamellate than in the type; from Reinsch's description and figures it is not easy to find any distinction between the two forms.

12. T. REGULARE Kützing, 1845, p. 129; *Polyedrium tetraedricum* Nägeli, 1848, p. 84, Pl. IV.B, fig. 3. Cells tetraedric, usually 14-50 μ diam., sides plane or slightly concave, angles obtuse, each with a short spine; membrane thick, distinctly lamellate.

Many varieties and forms have been described; we have only var. *longispinum* (Reinsch) De Toni, 1889, p. 605; *Polyedrium tetraedricum* var. *longispinum* Reinsch, 1888, p. 506, Pl. V, fig. 1a; P. B.-A., No. 1466. Spines longer, up to half the length of a side. Mass. *Europe.*

13. T. GIGAS (Wittr.) Hansgirg, 1888, p. 131; *Polyedrium gigas* Wolle, 1887, p. 184, Pl. CLIX, figs. 11-14; *P. tumidulum* var. *rotundatum* Reinsch, 1888, p. 506, Pl. VI, fig. 3a. Cells irregularly 5-6-angled, 65-75×35-45 μ, sides concave, angles unarmed. Me., Mass., Pa. *Europe, New Zealand.*

14. T. ARMATUM (Reinsch) De Toni, 1889, p. 611; *Polyedrium armatum* Reinsch, 1888, p. 508, Pl. VI, fig. 1. Cells 22-31 μ diam., with irregular, rounded sides, and 3 or 4 inconspicuous rounded angles, each with 1 or 2 stout spines, 5-8 μ long; membrane rather thick, not lamellate. Mass. *Europe.*

Beside the type we have var. *minus* Reinsch, 1888, p. 508, Pl. VI, fig. 1c; Cells 22 μ diam., flattened, with 3 nearly straight sides, and 2 spines at each angle.

15. T. BIFURCATUM (Wille) Lagerheim, 1893a, p. 160; *Polyedrium trigonum* var. *bifurcatum* Wolle, 1887, p. 184, Pl. CLIX, figs. 15-18. Cells tetraedric, about 30 μ diam., 3 or 4-angled, angles bifurcate, with sharp tips. Cuba, Porto Rico. *So. America.*

16. T. ENORME (Ralfs) Hansgirg, 1888, p. 132; *Polyedrium enorme* Wolle, 1887, p. 184, Pl. CLIX, figs. 19-23. Cells irregularly tetraedrical, generally 25-45 μ diam., angles prolonged, colorless, often deeply lobed, sometimes repeatedly forked; divisions mucronate. Me., Pa. *Europe.*

With many varieties and forms, based on dimensions and on the number and size of the angular projections; all passing into each other without any sharp line.

8. THAMNIASTRUM Reinsch, 1888, p. 513.

Cells solitary, free, composed of six branches issuing at right angles from a common center, di-trichotomously divided; ultimate divisions acute, spreading. Only one species.

T. CRUCIATUM Reinsch, 1888, p. 513, Pl. VIII, fig. 3. Characters of the genus; ultimate divisions 100-200, 1-2 μ diam. Fig. 49. Mass.

Nothing being known as to the reproduction of the plant, which has not been reported since its original discovery, its position here is provisional only, and based on habit characters.

9. CERASTERIAS Reinsch, 1867, p. 68.

Cells solitary, free, consisting of elongate rays from a common center, without distinct central body; otherwise as in *Tetraedron*.

Doubtfully distinct from *Tetraedron*, differing only in the greater development of the projections and consequent reduction of the main body.

KEY TO THE SPECIES OF CERASTERIAS.

| | |
|---|---|
| 1. Rays acute. | 1. *C. raphidioides*. |
| 1. Rays obtuse. | 2. *C. staurastroides*. |

1. C. RAPHIDIOIDES Reinsch, 1867, p. 68, Pl. V, fig. 1; 1888, p. 511. Rays 3-8, subulate, acute. Fig. 48. With many forms, of which we have two.

Var. INCRASSATUM Reinsch, 1888, p. 512, Pl. VIII, fig. 4 f. Cell consisting of 4 or 5 rays, 2.5-3×10-15 μ, 3 or 4 arranged in a whorl at one end of the other ray; or 2 or 3 in a whorl about one continuing the direction of the single ray, the single ray acuminate, other rays equal with rounded or sometimes acuminate ends. Mass. *Europe, Africa.*

Var. INAEQUALE Reinsch, 1888, p. 512, Pl. VIII, fig. 4, a-c. Single ray 10-15×2-3 μ, with acute lower end, at upper end with 3 similar acute rays, and 3 rays of about half the length, with obtuse ends. Mass. *Europe, Africa.*

2. C. STAURASTROIDES W. and G. S. West, 1895, p 268, Pl. XIV, fig. 16. Rays four, elongate, attenuate, minutely granulate, apex obtuse; thickness of central portion, 9-10 μ; total diam., 30-35 μ. On trees. Dominica.

*Polyedrium minutum* Larsen, p. 104, fig. 7, would seem to belong here, apparently intermediate between the two species.

10. SCHIZOCHLAMYS A. Braun in Kützing, 1849, p. 891.

Cells spherical or ellipsoid, irregularly distributed through the colorless gelatine, free floating or attached to water plants; chromatophore filling the cell, without pyrenoid; cell dividing into two daughter cells, the mother cell wall remaining in 2 or 4 pieces, about the new cells. Only one species.

S. GELATINOSA A. Braun in Kützing, 1849, p. 891; 1856, Pl. LII; P. B.-A., No. 369. Forming an irregular mass, up to 10 cm. long, pale or yellowish green; cells globose or ellipsoid, 11-14 $\mu$ wide, sometimes arranged by 2 or 4. Fig. 50. Me., Mass., Alaska, Cal. *Europe.*

Much like a *Tetraspora*, but not membranaceous, and distinguished by the persistent pieces of the mother cell wall, several generations of which may be found enclosed within the oldest.

11. ELAKATOTHRIX Wille, 1898, p. 302.

Cells ovoid or fusiform, with parietal chromatophore covering all the wall except at the ends, with a large pyrenoid; in a general gelatinous sheath; cell dividing by a cross wall, the daughter cells maintaining a longitudinal arrangement for a longer or shorter time.

E. AMERICANA Wille, 1899, p. 150; P. B.-A., No. 607; *Fusola viridis* Snow, 1903, p. 389, Pl. II, fig. VI. Cells ovoid or fusiform, 12-25 $\times$ 6-15 $\mu$, dividing across the middle, the daughter cells growing out obliquely, effacing the original longitudinal order; the gelatinous sheath in the form of a laciniate, anastomosing thallus, attached to various plants and reaching a length of several cm.; later forming floating masses of indefinite form. Fig. 51. Conn., Lake Erie.

12. HORMOTILA Borzi, 1883, p. 99.

Cells spherical, ovoid or ellipsoid, with one pyrenoid; either arranged 2-4-8-16 together in a wide, more or less firm, often concentrically lamellate gelatinous mass, which may form a considerably extended stratum; or distributed at intervals along colorless, branching, cylindrical, gelatinous bands. Asexual reproduction by zoospores, formed in ovoid sporangia, much larger than the vegetative cells; zoospores 8 or more in a sporangium, ovoid or ovoid-oblong, with red stigma, and prolonged to a point with two cilia; escaping through a lateral opening. Only one species.

H. MUCIGENA Borzi, 1883, p. 99, Pls. VIII and IX; P. B.-A., No. 1218. Cells 4-12 $\mu$ diam., sporangia to 30 $\mu$ diam., zoospores 3-5 $\times$ 1-2.5 $\mu$; mass reddish or bluish. On woodwork, etc., in standing fresh water. Fig. 52. Cal. *Europe.*

## 13. SCENEDESMUS Meyen, 1829, p. 774.

Colonies free, of 2-8 cells, in one row, or in two rows side by side; ovoid or with pointed ends, all smooth or all or part with spines or horns; chromatophore nearly filling the cell, with one pyrenoid; division either by longitudinal walls through each cell, or also by a wall through the length of a colony, dividing each cell across the middle; daughter cells escaping either singly or united in colonies; the free cells often differing considerably in form from the normal colony cells.

Common in gatherings of miscellaneous algae from still water; in such collections made in warm weather one is almost certain to find colonies of *Scenedesmus*; but it is unusual to find them constituting the bulk of a collecting.

KEY TO THE SPECIES OF SCENEDESMUS.

| | |
|---|---|
| 1. Ends of cells obtuse or rounded. | 2. |
| 1. Ends of cells acute. | 2. *S. obliquus.* |
| 2. Terminal cells of series with long projections. | 5. *S. quadricauda.* |
| 2. All cells similar. | 3. |
| 3. Cells without teeth or spines. | 1. *S. bijuga.* |
| 3. Cells with teeth or spines. | 4. |
| 4. Cells covered with minute spines. | 4. *S. Hystrix.* |
| 4. Cells with denticulate ends. | 3. *S. denticulatus.* |

1. S. BIJUGA (Turp.) Wittr., Nordst. and Lagerh., Alg. Exsicc., No. 1567; P. B.-A., No. 1220; *S. obtusus* Wolle, 1887, p. 173, Pl. CLVI, figs. 22-24. Colonies of 4-8 cells; cells oblong-ellipsoid or ovoid, with rounded ends, 7-18×4-7 μ, arranged in a single or double row. Greenland, Me., Mass., Neb., Cal. *Europe.*

Var. ALTERNANS (Reinsch) Hansgirg, 1886, p. 114; P. B.-A., No. 1181. Cells broader than in the type, in two rows, alternately placed; merely a form, hardly worthy of a name. Porto Rico, Cal. *Europe.*

Var. **flexuosus** (Lemmermann) nov. comb.; *S. bijugatus* var. *flexuosus* Lemmermann, 1898, p. 191, Pl. V, fig. 1; Snow, 1903, p. 375, Pl. I, fig. IV. Cells 8-16-32 in a single series, 10-20× 5-8 μ. Lake Erie. *Europe.*

2. S. OBLIQUUS (Turp.) Kützing, 1833, p. 609; P. B.-A., No. 1320; *S. acutus* Nägeli, 1848, Pl. V. A, fig. 3. Colonies of 4-8 cells, cells fusiform with acute ends, usually in a single series, 5-27×3-9 μ. Fig. 53. Me., Mass., Neb., Barbados, Cal. *Europe.*

Var. DIMORPHUS (Turp.) Hansgirg, 1886, p. 116; *S. acutus* var. *dimorphus* Rabenhorst, 1868. p. 64; *S. dimorphus* P. B.-A., Nos. 1020 and 1319. Cells united in a single series, end cells crescent-shaped, median cells straight. Me., Mass., Neb., Cal. *Europe.*

3. S. DENTICULATUS Lagerheim var. LINEARIS Hansgirg, 1886, p. 268. Colonies of 4-8 cells, in a nearly straight line, 4-5 $\mu$ wide, to 15 $\mu$ long; each end with two minute teeth. Greenland, Mass., Trinidad, Washington. *Europe.*

The type with ovoid or oblong cells, 7-8$\times$5-11 $\mu$, occurs in Europe, but has not yet been reported from America.

4. S. HYSTRIX Lagerheim, 1882, p. 62, Pl. II, fig. 18. Colonies 2-8-celled; cells oblong cylindric, straight with rounded ends, in a single series, 12-18$\times$3-6 $\mu$; membrane with numerous short spines. Porto Rico. *Europe.*

5. S. QUADRICAUDA (Turp.) Brébisson, 1835, p. 66; Ralfs, 1848, p. 190, Pl. XXXI, fig. 12; *S. caudatus* Wolle, 1887, p. 172, Pl. CLVI, figs. 11 and 12; P. B.-A., No. 1321. Colonies of 2-8 cells, oblong-cylindric with rounded ends, 9-33$\times$3-12 $\mu$, arranged in a single series or in two alternating rows; end cells usually with long, filiform projections; intermediate cells with rudimentary or no projections. Greenland, Me., N. H., Mass., Ohio, Neb., Wyo., Jamaica. *Europe, Asia, New Zealand.*

A very common species, the description above applying to the typical form; a number of varieties and forms have been described, of which we have probably a good part; the four following forms occur commonly:—*

Forma TYPICUS Kirchner, 1878, p. 98. Projections on terminal cells only.

Forma SETOSUS Kirchner, 1878, p. 98. Projections on some median cells.

Forma HORRIDUS Kirchner, 1878, p. 98. Projections on all cells.

Forma ABUNDANS Kirchner, 1878, p. 98; Wittr. & Nordst., Alg. Exsicc., No. 525. Terminal cells with median as well as terminal projections.

Var. ELLIPTICUS W. &. G. S. West, 1895a, p. 83, Pl. V, fig.

*Among the doubtful forms of the genus must be reckoned *S. rotundatus* Wood, 1872, p. 91; *S. polymorphus* Wood, 1872, p. 91; *S. antennatus* var. *rectus* Wolle, 1887, p. 172, Pl. CLVI, figs. 16 and 17.

6; G. S. West, 1905, p. 287. Cells perfectly ellipsoid, about $12 \times 5$ $\mu$, 4 in a single series, 2 strong spines, curved outward, on each terminal cell; the two median cells with one such spine each, in opposite directions. Barbados. *Madagascar.*

14. CRUCIGENIA Morren, 1830, p. 404.

Colonies free, of 4-8-16, rarely more cells, lying in the same plane, with perforations at places where the cells have divided and separated from each other; cells with parietal chromatophore and one pyrenoid, smooth or with prominences, touching at the middle or at the outer end, and enclosed in more or less plentiful gelatine; asexual reproduction by the division of a cell into 4 daughter cells, arranged like the mother colony. Fresh water plankton algae.

KEY TO THE SPECIES OF CRUCIGENIA.

1. Cells apiculate. 3. *C. apiculata.*
1. Cells not apiculate. 2.
 2. Cells ovoid, oblong, or somewhat curved, 4-32 in a colony. 1. *C. rectangularis.*
 2. Cells rhomboidal, 4 in a colony. 2. *C. crucifera.*

1. C. RECTANGULARIS (A. Br.) Gay, 1891, p. 100, Pl. XV, fig. 151; Wittr. and Nordst., Alg. Exsicc., Nos. 53, 171. Cells $4\text{-}6 \times 5\text{-}7$ $\mu$, 4-8-16-32 in a colony, 13-55 $\mu$ square, with rounded angles; always in groups of 4, with a quadrangular opening in the center of the group; fragments of the mother cell wall sometimes persistent; cells oval or oblong, touching near the outer end, or curved and touching near the middle. Fig. 54. Greenland, Mass. *Europe, Asia.*

2. C. **crucifera** (Wolle) nov. comb.; *Staurogenia cruciata* Wolle, 1887, p. 171, Pl. CLVII, figs. 9-11. Cells rhomboidal, equilateral, with incurved sides and rounded angles, four forming a colony of the same form as the individual cell; "cells with a cruciform marking on the surface." Wolle. Pa.

The figures given by Wolle are very rudimentary, but seem to indicate a distinct species. The cruciform marking of the cells is probably due to cell division in process.

3. C. APICULATA (Lemmermann) Chodat, 1902, p. 207; Snow, 1903, p. 376, Pl. I, fig. V. Cells elongate, ovoid, or by pressure at one end subtriangular, $5\text{-}8 \times 3\text{-}5$ $\mu$, with an apiculum at one end, sometimes at each end; united in fours or multiples of four in a flat, more or less regularly rectangular plate.

In reproduction each cell divides to form 4 daughter cells, which often remain attached by the general gelatinous envelop, forming a rectangular plate, which may measure as much as 150 $\mu$ on a side, and in which the number of cells is normally some power of four. Lake Erie. *Europe.*

15. SELENASTRUM Reinsch, 1867, p. 64.

Cells crescent or sickle-shaped, with parietal chromatophore and no pyrenoid; usually united in families of 4-8-16; asexual reproduction by division of cell into 4 daughter cells, which arrange themselves like the parent.

KEY TO THE SPECIES OF SELENASTRUM.

1. Cells less than 10 $\mu$ from tip to tip. 1. *S. minutum.*
1. Cells 16 $\mu$ or more from tip to tip. 2. *S. Bibraianum.*

1. S. MINUTUM (Näg.) Collins, P. B.-A., No. 1422; *Raphidium minutum* Nägeli, 1848, p. 82, Pl. IV.C, fig. 2. Cells crescent-shaped, usually uniformly curved; 7-9 $\mu$ from tip to tip to tip, 2-3 $\mu$ wide at middle; cells rarely continuing united, usually free. Fig. 55. Mass. *Europe.*

2. S. BIBRAIANUM Reinsch, 1867, p. 64, Pl. IV, fig. 2; P. B.-A., No. 1317. Cells crescent- or sickle-shaped, uniformly curved or with tips straight; families of four cells joined at the middle of the convex side of each cell; these four-celled families often united in subspherical colonies of 8 or 16 cells; cells 16-23 $\mu$ long, 5-8 $\mu$ wide at thickest part. Me., Mass., Wash. *Europe.*

16. KIRCHNERIELLA Schmidle, 1893, p. 83.

Cells arcuate or crescent-shaped, uninucleate, with parietal chromatophore and usually one pyrenoid, loosely aggregated without apparent order in a large gelatinous mass; asexual reproduction by division into 4 or 8 daughter cells.

K. LUNARIS (Kirchner) Moebius, 1894, p. 331; Chodat, 1902, p. 202, figs. 121 and 122. Cells crescent-shaped, with rounded ends, 3-5 $\mu$ diam. at middle, 6-10 $\mu$ long. Fig. 56. Me., Mass. *Europe.*

Var. DIANAE Bohlin, 1897, p. 20, Pl. I, figs. 28-30; P. B.-A., No. 1513. Cells more curved, tips acute and often not in the same plane. Me., Mass. *So. America.*

The genus differs from *Selenastrum* by the absence of any definite arrangement of the individual cells, and by the presence of an ample enclosing mass of gelatine. Both type and variety of *K. lunaris* occur among water plants in ponds, etc.

17. COELASTRUM Nägeli in Kützing, 1849, p. 195.

Cells spherical to polygonal, uninucleate, with bell-shaped chromatophore and one pyrenoid; asexual reproduction by successive division into 2-32 cells, escaping by the splitting of the mother cell wall into halves, still attached in part; cells remaining separate or uniting into a colony, spherical or sub-spherical, solid or hollow, joined by the gelatinous outer coating of the cell wall. Widely distributed fresh water plankton algae; here arranged chiefly according to Senn, 1899, which is a careful revision of the genus.

KEY TO THE SPECIES OF COELASTRUM.

1. Cells united by arm-like processes from the membrane. 5. *C. reticulatum.*
1. Cells in contact or united by quite short processes. 2.
  2. Cells with a short, free, external projection. 3.
  2. Cells without external projection. 4.
3. Interspaces about equal to diam. of cell. 3. *C. proboscideum.*
3. Interspaces much smaller than diam. of cell. 4. *C. cambricum.*
  4. Cells spherical or slightly elongate; interspaces very small. 1. *C. microporum.*
  4. Cells ovoid, mutually compressed; interspaces ½-1 cell diam. 2. *C. sphaericum.*

1. C. MICROPORUM Nägeli in A. Braun, 1855, p. 70; Senn, 1899, p. 53. Pl. II, figs. 11-17; P. B.-A., No. 1423. Cells 6-16 $\mu$ diam., spherical or slightly elongate and laterally compressed, united by the gelatinous surfaces; interspaces much smaller than the cell diam.; colony 40-55 $\mu$ diam. Mass., Pa., Porto Rico. *Europe.*

2. C. SPHAERICUM Nägeli, 1848, p. 98, Pl. V.C., fig. 1; Wittr., Nordst. and Lagerh., Alg. Exsicc., No. 1241. Cells 4-20 $\mu$ diam., ovoid, mutually much flattened, deformed mostly at the outer pole; intervals between the cells about equal to half the cell diam.; colony 20-90 $\mu$ diam. Cuba. *Europe.*

3. C. PROBOSCIDEUM Bohlin, 1897a, p. 33, Pl. II, figs. 19-22; Senn, 1899, p. 59, Pl. II, figs. 18-22; Wittr., Nordst. and Lagerh., Alg. Exsicc., No. 1240; *C. microporum* Wolle, 1887, p. 170, Pl. CLVI, figs. 1-3, not of Näg. Cells 7-40 $\mu$ diam., varying in form, but usually more or less angular, and with the outer pole prolonged in some form, and crowned with a gelatinous thickening, varying much in size and shape; colonies usually of 2-16 cells in a loose network with relatively large open spaces. Greenland, Me., Mass., N. J. *Europe, So. America.*

*C. microporum* var. *speciosum* Wolle, 1887, p. 170, Pl. CLVI, fig. 4, with projections like *C. proboscideum*, but with cells united by gelatinous filaments, is difficult to locate, and may possibly belong in another genus. Nothing can be determined until the plant is rediscovered.

4. C. CAMBRICUM Archer, 1868, p. 65; ?Wolle, 1887, p. 170, Pl. CLVI, fig. 5. Cells 6-12 μ diam., angular and somewhat lobed, with a truncate projection at the middle; interspaces quite small; colony 20-70 μ diam. Fig. 57. Mass. *Europe.*

5. C. RETICULATUM (Dangeard) Senn, 1899, p. 40, fig. 1. Cells 2-4-8-16, 6-24 μ diam., connected with each other by more or less numerous, arm-like prolongations of the membrane, forming a basket-like network about the spherical or spheroidal colony, which may continue intact for some time after the formation of daughter cells in each cell of the colony. Lake Erie. *Europe.*

### 18. SORASTRUM Kützing, 1845, p. 144.

Colonies unattached, solid, composed of 4-32 cordate, cuneate, reniform, or suboviform cells, which are united at the center of the colony by short stipes, and radially arranged; cells with 1-4 spines, projecting from the larger (external) end of each cell; chromatophore single, with one pyrenoid; asexual reproduction by the colony breaking up into its individual cells, which then, either at once or after division, develop each a new colony, which bursts through the membrane.

Differs from *Coelastrum* chiefly in the shape of the cells, and in that the colony breaks up before the development of the new colonies begins; but the reproduction is not fully understood.

KEY TO THE SPECIES OF SORASTRUM.

1. Outer angles of cells rounded, each with 2 spines.
   1. *S. spinulosum.*

1. Outer angles of cells ending each in a short, conical point.
   2. *S. bidentatum.*

1. S. SPINULOSUM Nägeli, 1848, p. 99, Pl. V.D; Wolle, 1887, p. 171, Pl. CLVI, figs. 6-10. Colony 23-60 μ diam.; cells 8-32, cuneate, outer end somewhat emarginate or subcordate, and with two pairs of spines about 15 μ long on each cell. Fig. 58. Me., Mass., Neb., Washington, Porto Rico. *Europe.*

2. S. BIDENTATUM Reinsch, 1867, p. 86, Pl. IV, fig. 1. Colony globose, about 30 μ diam., of 8-16 cells, wedge-shaped, elliptic in surface view, with a deep sinuate incision in the outer edge, the angles slightly prolonged and somewhat acute. Porto Rico. *Europe.*

### 19. DICTYOSPHAERIUM Nägeli, 1848, p. 72.

Cells originally spherical, with cup-shaped chromatophore and one pyrenoid; repeatedly dividing by twos and fours, the last generation being at the apices of dichotomous, gelatinous strands, radiating from the position of the original cell, and being part of the cell wall left behind in the course of the daughter cells outward; the whole enclosed in a general gelatinous mass; asexual reproduction by the transformation of a cell into a biciliate zoospore, germinating immediately, or by its division into 2-4 daughter cells, giving rise to a new colony. Widely distributed plankton algae.

KEY TO THE SPECIES OF DICTYOSPHAERIUM.

| | |
|---|---|
| 1. Cells ovoid or ellipsoid. | 1. *D. Ehrenbergianum.* |
| 1. Cells spherical. | 2. *D. pulchellum.* |
| 1. Cells reniform or cordate. | 3. *D. reniforme.* |

1. D. EHRENBERGIANUM Nägeli, 1848, p. 73, Pl. II. E; Wolle, 1887, p. 186, Pl. CLVI, figs. 29-31; Massee, 1891, p. 457, Pl. XII. Cells ovoid or ellipsoid, 6-10×4-7 μ, membrane thin; colonies ovoid or globose, of 16-64 cells, up to 80 μ diam. Fig. 59. N. J. *Europe.*

The first division of the cell is into four; all subsequent divisions into two, each division in a plane at right angles to the plane of the previous division; reproduction by biciliate zoospores, each formed from the contents of a cell, germinating immediately.

2. D. PULCHELLUM Wood, 1872, p. 84, Pl. X, fig. 4; Senn, 1899, p. 74, Pl. III, figs. 1-12; P. B.-A., No. 1511. Cells spherical, 5-9 μ diam., colonies up to 65 μ diam.; gelatinous coating ample, with distinctly radiate structure; reproduction not observed. Me., Mass., Pa. *Europe.*

3. D. RENIFORME Bulnheim, 1859, p. 22, Pl. II, fig. 6; Wolle, 1887, p. 186, Pl. CLVI, fig. 28; Rabenhorst, Algen, No. 789. Cells reniform or subcordate, usually 10-20×6-10 μ; colonies to 70 μ diam., somewhat irregular in form; gelatinous coating often with ciliate projections. Me., Mass., N. J., Pa. *Europe.*

20. DIMORPHOCOCCUS A. Braun, 1855, p. 44.

Cells on gelatinous strands radiating from the center, at the end of each strand 2-8 cells; all cells similar, or differing in the same group; chromatophore occupying only the middle part of the cell, with one pyrenoid.

Free floating plants, resembling *Dictyosphaerium*; the development not well understood.

D. CORDATUS Wolle, 1887, p. 199, Pl. CLX, figs. 30-38;

P. B.-A., No. 159. Cells all reniform to cordate, the lobes turned outward, 4-8 $\mu$ diam. Fig. 60. Me., Mass., N. Y., N. J., Pa., Fla.

The European *D. lunatus* A. Br. has cells in groups of four; two intermediate cells ovoid, obtuse; two lateral cells lunate; there is no certain record of its occurrence here, but it is to be expected.

21. DICTYOCYSTIS Lagerheim, 1890, p. 5.

Cells in series on gelatinous branching threads radiating from a central point; chromatophore star-shaped, with one pyrenoid.

D. HITCHCOCKII (Wolle) Lagerheim, 1890, p. 5; *Dictyosphaerium Hitchcockii* Wolle, 1885, p. 126; 1887, p. 186, Pl. CLVII, fig. 12. Cells 9-13$\times$15-20 $\mu$, ovoid, the longest dimension in the line of radiation. Fig. 61. N. J.

Removed from *Dictyosphaërium* on account of the stellate chromatophore, and the cells arranged along the gelatinous filaments, not merely at their ends.

## Family 5. HYDRODICTYACEAE.

Cells multinucleate, with net-shaped chromatophore, with one or more pyrenoids; united in families of definite form; asexual reproduction by biciliate zoospores, uniting to form a family either in the mother cell, or in a gelatinous vesicle issuing from it; sexual reproduction by gametes escaping from the mother cell, and by copulation forming a resting zygote, from which, by various intermediate stages, the normal vegetative form is produced. Fresh water plants.

KEY TO THE GENERA OF HYDRODICTYACEAE.

1. Colonies net-shape. 1. HYDRODICTYON.
1. Colonies disk-shape. 2. PEDIASTRUM.

1. HYDRODICTYON Roth, 1800, p. 531.

Colonies unattached, composed of very many cylindrical multinucleate cells united at the ends by three, rarely by two or four, to form a cylindrical, wide-meshed net with closed ends; cells all alike; asexual reproduction by zoospores, formed in great numbers in a cell, finally arranging themselves in a minute net, which is freed by the breaking up of the mother cell; sexual reproduction by zoogametes formed in still larger numbers in a cell, and escaping by an opening, either conjugating or developing parthenogenetically; from the resting spore thus formed come 2-5 large zoospores, developing into irregular angular cells, "polyhedra" in which are developed many small zoospores, uniting to form a new net. Only one species.

H. RETICULATUM (L.) Lagerheim, 1883, p. 71; Kützing, 1856, Pl. XXXV; Wolle, 1887, p. 169, Pl. CLIV, figs. 11-20; P. B.-A., No. 65. Cells usually several diameters long, length up to 1 cm., 100-200 $\mu$ wide; families 1 or 2 dm. long; zoospores to 20,000 in a cell, gametes to 100,000. Fig. 62. Generally distributed in fresh water. *Europe.*

A very attractive plant in appearance, the net-like frond being found from microscopic size to one or two dm. in length, the cells and meshes varying correspondingly.

2. PEDIASTRUM Meyen, 1829, p. 772.

Colonies unattached, disk-shaped, of round or star-shaped outline, continuous or perforate, composed of marginal cells of different shape from the interior cells; cells multinucleate, with net-form parietal chromatophore and one pyrenoid; asexual reproduction by biciliate zoospores, which escape from the cell enclosed in a vesicular coating, within which they arrange themselves to form a new colony; or by the formation of a new colony in a cell, without intervention of zoospores; sexual reproduction by smaller gametes, more in a cell, copulating to form an irregular Polyedrium-like zygote, within which a new colony is formed, in the same way as in a cell of the mother colony.

Species of this genus are common in fresh water plankton, and in most gatherings of miscellaneous algae from quiet water in warm weather. Their regular disks, continuous or openwork, with variously toothed or spiny marginal cells, are interesting objects; but while types of the species seem clearly distinct, in practice many intermediate forms will be found.

A rather conservative course has been followed as regards recognizing species; but it should be noted that Chodat, 1902, p. 224, includes as forms of *P. Boryanum*, the species *P. forcipatum*, *P. vagum* and *P. angulosum*; this may sometime be fully justified, but for the present it will be more convenient to retain them as species.

KEY TO THE SPECIES OF PEDIASTRUM.

1. Marginal cells undivided, cuspidate. 8.
1. Marginal cells bilobed. 2.
 2. Lobes of marginal cells simple. 3.
 2. Lobes of marginal cells emarginate, bidentate or bifid. 7.
3. Disk continuous. 4.
3. Disk perforate. 7. *P. duplex.*

4. Lobes of marginal cells incurved, forcipate. 3. *P. forcipatum.*
4. Lobes of marginal cells straight or nearly so. 5.
5. Margin finely tuberculate-crenulate. 5. *P. vagum.*
5. Margin not tuberculate-crenulate. 6.
6. Lobes ending in short, broadly triangular teeth. 6. *P. angulosum.*
6. Lobes ending in linear teeth. 4. *P. Boryanum.*
7. Disk continuous. 8. *P. tetras.*
7. Disk perforate. 9. *P. biradiatum.*
8. Marginal cells with a single tooth or cusp. 1. *P. simplex.*
8. Marginal cells tridentate. 2. *P. tricornutum.*

1. P. SIMPLEX Meyen, 1829, p. 772, Pl. XLIII, figs. 1-5; Wolle, 1892, p. 168, Pl. LXIV, fig. 17; Wittr. and Nordst., Alg. Exsicc., No. 524. Family of 8-16, rarely 32 cells, up to 75 $\mu$ diam.; arrangement much varied, disk continuous or perforate; each marginal cell ending in a single aculeate tooth or spine.

Var. STURMII (Reinsch) Wolle, 1892, p. 168, Pl. LXIV, fig. 18. Cells arranged in one or two series about a large central open space.

Var. DUODENARIUM (Bailey) Rabenhorst, 1868, p. 71; Wolle, 1892, p. 169, Pl. LXIV, fig. 20. Disk with a central open space, surrounded by four cells, four openings in the form of arcs of circles between these cells and the 12 cells of the outer row. Mass., N. Y., Ohio, Ill. *Europe, So. America.*

These varieties are hardly worthy to be distinguished by name, being merely two of the many forms assumed by this species. None of the forms, however, need be mistaken for any other species, as there is no other species in which each cell ends in a long, aculeate projection.

2. P. TRICORNUTUM Borge, 1892, p. 4, fig. 3. Disk continuous, rounded, 32-40 $\mu$ diam.; marginal cells 10-18 $\times$ 9-10 $\mu$, trapeziform, with three teeth on the margin; disk cells polygonal. Greenland. *Northern Europe.*

3. P. FORCIPATUM (Corda) A. Braun, 1855, p. 86; Wolle, 1892, p. 169, Pl. LXIV, figs. 21, 30-31. Cells 8-16, rarely more, forming a continuous disk; disk cells about 24 $\mu$ wide, polygonal or slightly incurved on the outer side; marginal cells deeply incised, bilobed, lobes incurved, acuminate. Mass., N. J., Pa. *Europe.*

The small disks, and especially the forcipate prolongations of the marginal cells, seem sufficiently characteristic.

4. P. BORYANUM (Turp.) Meneghini, 1840, p. 210; Nägeli, 1848, p. 95, Pl. V.B, fig. 1; Wolle, 1892, p. 169, Pl. LXIV,

figs. 29-32; P. B.-A., No. 1180. Cells 4-64, rarely 128, 10-20 $\mu$ wide, forming a continuous, circular or elliptical disk; disk cells 4-6-angled, the external side varying from prominent to repand; marginal cells more or less emarginate or bilobed, each lobe ending in a longer or shorter terete, obtuse to capitellate projection. Fig. 63. Greenland, Me., Mass., N. J., Pa., Ohio, Ill., Neb., Cal., Alaska. *Europe, Asia, So. America.*

A very common and widely distributed species, with many varieties; to be recognized more by the general combination of characters than by any one detail, though the two terete prolongations from each marginal cell are usually sufficiently characteristic.

Var. UNDULATUM Wille, 1879, p. 28; *P. undulatum* (Wille) Boldt, 1893, p. 157, fig. 1. Cells sometimes 256; larger than in the type; disk cells with irregularly undulate margin; marginal cells distinctly bilobed. Greenland. *Europe.*

Var. GRANULATUM (Kütz.) A. Braun, 1855, p. 90; P. B.-A., No. 1324; with smaller cells and families, and verrucose membrane. Greenland, Nebraska and California.

5. P. VAGUM Kützing, 1845, p. 143; A. Braun, 1855, p. 82, Pl. VI, figs. 27-28; P. B.-A., No. 1519. Cells 32-128 in a disk, disk continuous, of varying form, up to 250 $\mu$ wide, cells in disk to 30 $\mu$ wide, 5-6-angular; marginal cells about 10 $\mu$ wide, with two short, obtusely triangular projections; margin and membrane generally finely tubercular-crenulate. Greenland, Me., Mass. *Europe, So. America.*

The large disk of irregular form, composed of many cells, with the crenulate margin, makes this quite a distinct species.

6. P. ANGULOSUM (Ehrenb.) Meneghini, 1840, p. 211; A. Braun, 1855, p. 84, Pl. VI, fig. 26; Wolle, 1892, p. 169, Pl. LXIV, fig. 28. Cells 16-64, up to 19 $\mu$ diam., 5-6-angular, forming a continuous disk, up to 120 $\mu$ diam.; marginal cells with truncate base, wider above, with a more or less deep sinus, the inner side of the ray prolonged in a slightly incurved tooth, the outer edge with a slight apiculum. Me., N. J., Ohio, Neb., Alaska. *Europe, Asia.*

Each marginal cell has a projection on each side of the central rounded sinus; the inner edge of this terminates in a sublinear tooth, not exactly on the radial line, but parallel to the tooth on the other side of the sinus; the outer edge of the projection has merely a small apiculum, as if produced by the pressure of the adjacent cell.

7. P. DUPLEX Meyen, 1829, p. 772, Pl. XLIII, figs. 6-20; *P. pertusum* Wolle, 1892, Pl. LXIV, figs. 33, 34; Wittr. and Nordst., Alg. Exsicc., No. 1237. Cells 8-32, 6-28 $\mu$ wide, forming a disk perforate with many rounded openings of varying size; disk cells quadrangular, or emarginate on one or more sides; marginal cells joined only at the base, deeply bilobed, lobes straight, each ending in an acute or obtuse, not capitellate prolongation. Mass., Me., N. J., Ill., Neb. *Europe.*

A common species, and with many varieties; but fairly well recognized by the numerous rounded openings.

Var. CLATHRATUM A. Braun, 1855, p. 93; Wittr. and Nordst., Alg. Exsicc., No. 1562. Disk cells deeply emarginate, making the openings proportionally larger than in the type. Mass., Neb. *Europe.*

Var. BRACHYLOBUM A. Braun, 1855, p. 93, Pl. VI, fig. 25; Wolle, 1892, Pl. LXIV, fig. 35. Disk and marginal cells only slightly emarginate; openings and marginal projections inconspicuous. Me. *Europe.*

8. P. TETRAS (Ehrenb.) Ralfs, 1844, p. 469, Pl. XII, fig. 4; *P. Ehrenbergii* A. Braun, 1855, p. 97, Pl. V.H.; Wolle, 1892, p. 170, Pl. LXIV, figs. 25-27. Cells 4-16, 9-20 $\mu$ wide, disk cells polygonal, one side repand or with a very deep and narrow incision; marginal cells very deeply incised, lobes emarginate, bidentate or bifid. Me., Mass., N. J., Ohio, Ill., Neb., Colo., Porto Rico, Mexico. *Europe, Asia, So. America.*

The small continuous disk, with deep linear incisions in nearly every cell, and with cell lobes divided, easily identifies this species.

9. P. BIRADIATUM Meyen, 1829, p. 773, Pl. XLIII, figs. 21-22; *P. rotula* A. Braun, 1855, p. 101, Pl. VI, figs. 1-3. Cells 8-32, 9-21 $\mu$ wide; disk cells deeply incised, leaving rather large openings; marginal cells attached at the base only, incised to or below the middle, each division ending in two acute or obtuse denticulations. Greenland. *Europe.*

From *P. duplex*, which has a similarly perforate frond, this can be distinguished by the double division of the marginal cells, giving two projections to each lobe.

Var. EMARGINATUM (A. Braun) Lagerheim, 1882, p. 54; *P. rotula* var. *emarginatum* A. Braun, 1855, p. 102, Pl. VI, figs. 4, 8, 9, 11. Disk cells slightly sinuate-emarginate; marginal cells less deeply incised, divisions emarginate, bidentate or subtruncate. Greenland. *Europe.*

## Order ULOTRICHALES

Simple or branched filaments, sometimes membranes, rarely in few-celled families; cells uninucleate, chromatophore usually single, band-, disk-, net-, or star-shape, generally with one or more pyrenoids. Marine and fresh water.

KEY TO THE FAMILIES OF ULOTRICHALES.

1. Chromatophore star-shaped; zoospores unknown. 3. PRASIOLACEAE.
1. Chromatophore net-, disk- or band-shaped. 2.
 2. Cells usually red or brown by haematochrome; frond filamentous, branching. 9. CHROOLEPIDACEAE.
 2. Vegetative cells true green. 3.
3. Fronds unbranched filaments. 4.
3. Fronds branched or membranaceous, rarely in few-celled families. 6.
 4. Sexual reproduction by isogamous gametes. 1. ULOTRICHALES.
 4. Sexual reproduction by oogonia and antheridia. 5.
5. Chromatophore net-shaped. 5. OEDOGONIACEAE.
5. Chromatophore disk- or band-shaped. 4. CYLINDROCAPSACEAE.
 6. Frond membranaceous, either flat or forming a tube. 2. ULVACEAE.
 6. Frond filamentous, branching, or a few-celled family; usually with hairs. 7.
7. Sexual reproduction by isogamous zoogametes. 6. CHAETOPHORACEAE.
7. Sexual reproduction by oogonia and antheridia. 8.
 8. Vegetative filaments prostrate. 9.
 8. Vegetative filaments erect. 5. OEDOGONIACEAE.
9. Oospore with cellular envelope; vegetative filaments radiate or united to a disk. 8. COLEOCHAETACEAE.
9. Oospore without cellular envelope; vegetative filaments irregularly spreading. 7. HERPOSTEIRACEAE.

### Family 1. ULOTRICHACEAE.

Frond a normally unbranched, uniseriate filament, rarely partly multiseriate, of uninucleate cells, each of which, with the exception of the basal cell, when present, is capable of producing spores or gametes. Chromatophore either a single, complete or broken band, or a network, or one to several disks; usually with one or more pyrenoids. Asexual reproduction by bi- or 4-ciliate zoospores, by akinetes, or by aplanospores; sexual reproduction by the conjugation of biciliate zoogametes.

A family of fresh water and marine algae, fairly well marked off from other forms by the characters just given; but it is by no means easy to determine by hasty inspection whether a plant belongs to this family or to the *Cladophoraceae*. In external appearance and even by ordinary microscopic inspection, there is no test to distinguish *Ulothrix*, *Hormiscia*, or *Chaetomorpha;* only by actual acquaintance with the individual species can one acquire any certainty of determination.

In the arrangement of this family Hazen, 1902, has been followed, except that *Conferva* has been removed. While there may be some doubt as to the distinctness of all the species he has accepted, and he himself expresses some such doubt, his work represents the only careful and continued study that has been made of the living plants in this country, and may well be accepted until modified by later investigations.

KEY TO THE GENERA OF ULOTRICHACEAE.

1. Filaments monosiphonous below, parenchymatous above. 4. SCHIZOMERIS.
1. Filaments monosiphonous throughout. 2.
  2. Cells loosely attached, in a wide, gelatinous sheath. 3. RADIOFILUM.
  2. Cells forming a cylindrical or moniliform filament, without external gelatinous sheath. 3.
3. Without pyrenoid. 6. MICROSPORA.
3. With one or more pyrenoids. 4.
  4. Chromatophore a parietal disk or plate. 5. STICHOCOCCUS.
  4. Chromatophore a zonate band, sometimes incomplete. 5.
5. Apical and basal cells attenuate. 2. URONEMA.
5. Apical and basal cells little if at all differentiated. 1. ULOTHRIX.

1. ULOTHRIX Kützing, 1833, p. 517.

Filaments of a single series of uninucleate cells, all similar, and, with the exception of the attached basal cell, capable of division and of producing spores. Chromatophore band-shaped, with one or more pyrenoids. Asexual reproduction by aplanospores and akinetes, also by 4-ciliate zoospores, with red stigma, formed 1-4 in a cell, germinating immediately; sexual reproduction by biciliate zoogametes formed 8 or more in a cell, germinating after conjugation. External conditions may induce many modifications of the normal process; resting spores may be formed, ultimately producing zoospores; filaments may break up into individual cells, and these by copious formation of gelatine pass into a Palmella or a Gloeocystis condition.

A genus of marine and fresh water species, of world-wide distribution; by no means easy to distinguish from species of *Hormiscia*, *Chaetomorpha*, etc., whose filaments are also of a single series of cylindrical or somewhat inflated cells. The number of nuclei can be ascertained only by careful examination, and while the shape of the chromatophore is of a different type in each genus, the variations from the type are many and perplexing. In herbarium specimens the chromatophore characters are usually indistinct. In general, *Chaetomorpha* is firmer and stiffer, and has longer cells than *Ulothrix*; none of our species of *Ulothrix* exceeds 50 μ diam., while few species of *Chaetomorpha* are less than 100 μ diam. *Hormiscia* species also are usually of larger dimensions than *Ulothrix* species, but there is little difference in cell length or consistency. As between the two genera, the only tests are the number of nuclei, requiring pretty careful study, and the form of the zoospores, ascertainable only occasionally. As regards dried specimens, only personal acquaintance with the various species, or comparison with authentic specimens, is of any use.

KEY TO THE SPECIES OF ULOTHRIX.

| | |
|---|---|
| 1. Marine or brackish. | 2. |
| 1. Fresh water. | 5. |
| 1. Thermal. | 2. *U. caldaria.* |
| 2. Occasionally branching. | 12. *U. lactevirens.* |
| 2. Always simple. | 3. |
| 3. Cells usually much shorter than their diameter. | 10. *U. flacca.* |
| 3. Cells usually longer than their diameter. | 4. |
| 4. Chromatophore a more or less complete ring at the middle of the cell. | 9. *U. implexa.* |
| 4. Chromatophore a curved lateral disk, extending from the pyrenoid in all directions, but not filling the cell. | 11. *U. subflaccida.* |
| 5. Filaments not over 9 μ diam.; pyrenoid single. | 6. |
| 5. Filaments 11-45 μ diam.; pyrenoids several. | 7. |
| 6. Filaments 7-9 μ diam. | 3. *U. tenerrima.* |
| 6. Filaments 5-6 μ diam. | 1. *U. variabilis.* |
| 7. Mature filaments 25-45 μ diam. | 8. *U. zonata.* |
| 7. Filaments not over 20 μ diam. | 8. |
| 8. Filaments torulose. | 6. *U. moniliformis.* |
| 8. Filaments not torulose. | 9. |
| 9. Cells 1-2 diam. long. | 7. *U. aequalis.* |
| 9. Cells not over ½ diam. long. | 10. |

10. Cells 15-20 μ diam. 4. *U. tenuissima.*
10. Cell 11 μ diam. 5. *U. oscillarina.*

1. U. VARIABILIS Kützing, 1849, p. 346; Hazen, 1902, p. 152, Pl. XXI, figs. 5-7; P. B.-A., Nos. 1022, 1373; ? *U. subtilis* var. *variabilis* Wolle, 1887, p. 136, Pl. CXVIII, figs. 15-16. Filaments 5-6 μ diam., cells cylindrical, ½-1½ diam. long, wall very thin and delicate; chromatophore usually occupying about half the cell wall, often quite irregular in shape and position; pyrenoid single, small. *Europe.*

This species forms floccose masses in brooks and quiet waters. It has been reported from Greenland, a few localities in the eastern States, from Trinidad, and from California.

2. U. **caldaria** (Kütz.) nov. comb.; *Gloeotila caldaria* Kützing, 1849, p. 363; 1853, p. 10, Pl. XXXII, fig. 3; *U. subtilis* var. *thermarum* Wolle, 1887, p. 136, Pl. CXVIII, figs. 18 and 19; *Hormiscia flaccida* var. *caldaria* Tilden, Amer. Algae, No. 130. Filaments soft and mucilaginous, bright or dull green, 5-8 μ diam., cells 1-3 diam. long, cylindrical; chromatophore (in dried specimens) apparently occupying the entire cell wall. Forming long strings and floccose masses in warm or hot water. Yellowstone Park; Pa. *Europe.*

Our only distinctly thermal species.

3. U. TENERRIMA Kützing, 1843, p. 253, Pl. IX, fig. 1; Hazen, 1902, p. 151, Pl. XXI, figs. 3 and 4; P. B.-A., No. 1468. *U. subtilis* var. *tenerrima* Wolle, 1887, p. 136, Pl. CXVIII, fig. 17. Forming light green silky masses, often of considerable length; filaments 7-9 μ diam.; cells cylindrical, ⅔-1⅓ diam. long; wall very thin; chromatophore zonate, or contracted to one side of the cell; pyrenoid single. Vt., Mass., Cal. *Europe.*

The single pyrenoid seems to distinguish this species from all others except *U. variabilis;* these two species are certainly quite near each other, but *U. tenerrima* is a larger species, with the chromatophore more fully and regularly developed. The material from California distributed as P. B.-A., No. 1468, is in the Gloeocystis state, and its connection with this species though probable is not certain.

4. U. TENUISSIMA Kützing, 1833a, p. 518; Hazen, 1902, p. 149, Pl. XX, figs. 5 and 6; P. B.-A., No. 1021. Filaments dark green, 15-20 μ, rarely 25 μ diam.; cells cylindrical, except when fruiting, about ½ diam. long; chromatophore a broad band.

This species resembles young conditions of *U. zonata*, and even Hazen, on whose authority it is given, is in doubt if it may not have to be included in the commoner species when better known. The distinctions are in the darker color, thinner cell wall and shorter cells, characters which are notoriously variable in this genus. The only localities are near New York city and in Alaska. *Europe.*

5. U. OSCILLARINA Kützing, 1845, p. 197; ? Wolle, 1887, p. 137, Pl. CXVIII, figs. 34-36; Hazen, 1902, p. 150; P. B.-A., No. 613. Forming soft mucilaginous masses; filaments about 11 $\mu$ diam.; cells ¼-½ diam. long, rarely 1 diam.; chromatophore a broad band. Mass. *Europe.*

In quiet or slowly running water. The short cells and soft, mucilaginous consistency are the chief distinguishing characters. Wolle reports it from Wisconsin, but if his figure is drawn from Wisconsin specimens, there might be some question as to the identity of his plant with the present species. Hazen reports the specimens in the Wolle herbarium not to be *Ulothrix*. *U. oscillarina* appears to be a plant of summer rather than of spring.

6. U. MONILIFORMIS Kützing, 1849, p. 347; 1852, Pl. LXXXVIII, fig. 4; Hazen, 1902, p. 157; P. B.-A., No. 612. Filaments 11-14 $\mu$ diam., more or less crisped, torulose, light green, with thick walls; cells about as long as broad. *Europe.*

This may be the fruiting condition of some other species, but it has not yet been identified with any, and it is quite distinct in form from any of the species here recorded. It has only one authentic locality with us, in Conn.

7. U. AEQUALIS Kützing, 1845, p. 197; Wolle, 1887, p. 134, Pl. CXVIII, figs. 3-5; Hazen, 1902, p. 150; Phyk. Univ., No. 577. Filaments 13-16 $\mu$ diam., cylindrical, cells 1-2 diam. long. *Europe.*

A rather imperfectly known species, but considered quite distinct by Hazen. The only definite locality is near New York City.

8. U. ZONATA (Web. and Mohr) Kützing, 1833a, p. 519; Wolle, 1887, Pl. CXVII, figs. 1-19; Hazen, 1902, p. 147, Pl. XX, figs. 1-4; P. B.-A., Nos. 19a and 1023. Forming yellowish green masses; filaments usually 30-40 $\mu$ diam., sometimes as low as 11 $\mu$ at the base of young filaments, rarely 45 $\mu$ in old

filaments; cells cylindrical or somewhat swollen, 1/3-1 1/2 diam. long when full grown, longer in young filaments; cell wall at first thin, growing thicker; chromatophore a broad or narrow band at the middle of the cell, with several large pyrenoids. Fig. 64. Greenland, Northern U. S. from Me. to Alaska. *Europe.*

A common species in spring, attached to sticks or stones in streams or pools; the filaments are nearly the same diameter throughout, or smallest at the base, considerably larger above; the cells are usually actually as well as relatively longer near the base. It is not likely to be mistaken for other fresh water species of *Ulothrix*, but it is not unlike *Microspora crassior* and *M. amoena*, which occur in similar stations. The characters of the chromatophores and of the cell wall can be depended on for distinction in the living plant.

9. U. IMPLEXA Kützing, 1849, p. 349; 1852, Pl. XCIV, fig. 2; Hazen, 1902, p. 153, Pl. XXI, figs. 1 and 2; P. B.-A., No. 115. Forming light green, soft masses, cells 6-15 $\mu$ diam., sometimes slightly swollen at the middle, about as long as broad, chromatophore occupying only the middle part of the cell, often an incomplete ring. Atlantic coast and Alaska. *Europe.*

Rather common from New Jersey to Greenland, usually near high water mark, and where it is more or less exposed to the influence of fresh water; most frequent in spring. Reported from Florida by Wolle, but the identification is doubtful.

10. U. FLACCA (Dillw.) Thuret in Le Jolis, 1863, p. 56; Farlow, 1881, p. 45; Hazen, 1902, p. 155, Pl. XX, figs. 7-9; P. B.-A., Nos. 17, 1123; *Hormotrichum speciosum* and *H. boreale* Harvey, 1858, p. 90. Forming bright or dark green, often much entangled masses or skeins; cells 10-25 $\mu$ diam., 1/4-3/4 as long as broad; when producing spores up to 50 $\mu$ broad, and swollen in the middle; chromatophore occupying the whole of the cell wall. Atlantic and Pacific coasts. *Europe.*

Common between tide marks from New Jersey to Greenland, and occurring on the Pacific coast from Washington to California; in southern New England chiefly on *Fucus* and *Spartina* (Hazen, 1902, p. 156); more northerly, abundant on rocks and woodwork, often forming, in company with *Hormiscia penicilliformis* and *Bangia fusco-purpurea*, a band along the shore between half tide and low water mark, for a long distance. It is most abundant in winter and spring, but is found more or less throughout the year.

Several species have been segregated by Wille, 1901, from *U. flacca;* the new species are not at all easy to distinguish, except when living; probably all have passed as forms of *U. flacca* in this country. The most certain marks of this species are the always free filaments, with short cells, quite occupied by the chromatophore, which is of nearly even thickness throughout.

11. U. SUBFLACCIDA Wille, 1901, p. 27, Pl. III, figs. 90-100; P. B.-A., No. 1275. Filaments 5-25 $\mu$ diam., attached by a rounded basal cell; cells 1-2 diam. long, rarely more or less; chromatophore a curved parietal disk, with one pyrenoid; zoospores formed 8 in a cell, broadly ovoid.

Segregated from *U. flacca* by Wille, this species is to be recognized chiefly by the longer cells, with the chromatophore quite thick at one side, where the pyrenoid is situated, thinner in all directions, often not extending around the cell or to the ends. The only locality with us is at California, where it was found growing on a steamer whose daily route passed from fully salt to fully fresh water. Such exceptional conditions would naturally have their results on the plant, and it is of course possible that under more normal conditions it would be different. At present it answers well to Wille's species.

12. U. **laetevirens** (Kütz.) nov. comb.; *Schizogonium laetevirens* Kützing, 1845, p. 194; P. B.-A., No. 313. (?) *U. consociata* Wille, 1901, p. 25, Pl. II, figs. 82-89. Filaments 10-25 $\mu$ diam., two or three often firmly grown together laterally, more or less entangled and creeping; with not infrequent branches, issuing at a wide angle, and usually much more slender than the main filament, of many cells, which are generally 1-3 diam. long; filaments tapering towards the base, the lower cells of the densely packed filaments often subparenchymatously united; cells $\frac{1}{4}$-$\frac{3}{4}$ diam. long, rarely more; chromatophore covering nearly or quite all of the cell wall, but thicker at one side, where the pyrenoid is situated; zoospores usually 8 in a cell; akinetes formed singly from the cells. On woodwork between tides. Canada, Me., Cal. *Europe.*

The Canadian plant grew on alder logs at Cap à l'Aigle; the material distributed as P. B.-A., No. 313, on fence rails between tide marks, at Eagle Island, Penobscot Bay, Maine. This material agrees very well with authentic specimens of *Schizogonium lactevirens* from Calvados, the locality given by Kützing; whether *Bangia laetevirens* Harvey in Hooker, 1833, p. 317, is the same, can hardly be determined; that species is ignored by Harvey in his later works.

The description of *U. consociata* Wille would seem to indicate the same species. It is our only species of this genus with branching filaments; the laterally united filaments are also characteristic, resembling those of *Schizogonium*; they arise, however, by the union of distinct filaments, not by longitudinal division of a single filament.

The genus *Hormospora* Brébisson, has cells practically like those of *Ulothrix*, but located at a greater or less distance from each other in a relatively large gelatinous filament. Several species have been described, but Cienkowski, 1876, has shown that under certain conditions a species of *Ulothrix* passed into a state agreeing perfectly with the description of *Hormospora*, and then by further development into a *Palmella* state. Gay, 1891, states that he has examined a number of authentic specimens of the original species, *H. mutabilis* Bréb., and found all stages from normal *Ulothrix* to typical *Hormospora*. At least four species in this genus were proposed by Wolle at different times, but in Wolle, 1887, pp. 133, 189, he appears to have given up his belief in them. In Pl. CXXIV of the same work are figured a number of forms, one of which, *H. purpurea* Wolle, 1880, p. 22, seems to be a good species, but until more is known of its life history, its affinities must be doubtful, but with a probability that it belongs with the *Rhodophyceae*, among the *Bangiaceae*. It has been distributed from Pa. in Wittr., Nordst. and Lagerh., Alg. Exsicc., No. 1358, and from N. H. in P. B.-A., No. 1374. Fig. 65.

The only other species for which there is a record in this region has recently been described by G. S. West, who thinks that the genus should be maintained, at least provisionally. As this species is quite different from species previously described, and, if a condition of *Ulothrix*, probably related to some undescribed species, it appears well to give the description here.

H. SCALARIFORMIS G. S. West, 1905, p. 282, Pl. CCCCLXIV, figs. 6 and 7. Cells narrowly oblong-ellipsoid, rather distant, 7-8.5 by about 2.5 $\mu$, set transversely in the cylindrical, gelatinous filaments, 13-17 $\mu$ diam. Barbados.

2. URONEMA Lagerheim, 1887, p. 517.

Filaments attached, simple, of a single series of cells, apical and basal cells attenuate; chromatophore a parietal disk, with two pyrenoids, rarely only one pyrenoid; asexual reproduction by 4-ciliate zoospores produced singly, sometimes two, in any cell of the filament, escaping by an opening, germinating at once; also by aplanospores, formed one in a cell. Only one species.

U. CONFERVICOLA Lagerheim, 1887, p. 518, Pl. XII, figs. 1-10; Wittr. and Nordst., Alg. Exsicc., No. 910. Filaments up to 1 mm. long, solitary, cylindrical, apical cell acuminate, basal cell attenuate, terminating in a callus; cells 4-6 $\mu$ diam., 2½-4 diam. long, basal and terminal cells considerably longer; usually attached to other algae. Fig. 66. W. I., Cal. *Europe.*

Gaidukow, 1903, claims that under certain conditions a plant that he designates as *Ulothrix flaccida* var. *genuina* Hansgirg, developed filaments with pointed ends; and that therefore *Uronema* should be, at most, merely a subgenus of *Ulothrix*. There might be some question as to what species Gaidukow had under investigation; Hansgirg gave a very broad extension to *Ulothrix flaccida*, and his views on polymorphy of algae are well known; as here understood, *Ulothrix flaccida* Kütz. belongs in the genus *Stichococcus*, having only one pyrenoid to a cell, biciliate asexual zoospores, and no differentiated basal cell. This certainly does not agree with *Uronema*, and as *U. confervicola* has been found in very distant stations, practically the same, it seems best to retain it, pending further developments.

3. RADIOFILUM Schmidle, 1894, p. 47.

Cells usually not as long as broad, subglobose, ellipsoid or lenticular, with parietal chromatophore and one pyrenoid, arranged in longitudinal series, in a wide, gelatinous, cylindrical sheath.

R. APICULATUM W. and G. S. West, 1895b, p. 52; Bohlin, 1897, p. 10, Pl. I, figs. 6-8; P. B.-A., No. 1421. Cells lenticular with sharp edge, about 6 μ diam., 4 μ thick, set transversely in a transparent gelatinous sheath, 20-25 μ diam. Fig. 74. Mass. *So. America.*

The filaments of this species are found among various unattached algae in quiet water. The cell wall appears to consist of two equal parts, something like two soup plates set face to face; in the filament these show the edge view, the outline being an oval with acuminate ends.

4. SCHIZOMERIS Kützing, 1843, p. 247.

Frond filiform, unbranched, of a single series of cells below, increasing in size above, cells dividing in all directions; reproduction by biciliate zoospores with red stigma; asexual (?). Fresh water.

Only one species.

S. LEIBLEINII Kützing, 1843, p. 247, Pl. XII, fig. 1; Wolle, 1887, Pl. CXXV.; P. B.-A., No. 69. Frond up to 20 cm. high, rather stiff, 20-25 μ diam. at base, up to 150 μ above; terete below, with more or less deep and frequent constrictions above; cells 15-30 μ diam., roundish or angular, with rather thick, often lamellate membrane; zoospores formed in the upper part of the frond, freed by the breaking of the cross walls, the side walls dissolving later; zoospores thus issuing from the summit of the frond. Fig. 67. In quiet fresh water. Mass., R. I., N. J., Pa., Fla. *Europe, So. America.*

5. STICHOCOCCUS Nägeli, 1848, p. 76.

Filaments without special basal cell, slender, consisting of few or many cells; chromatophore a parietal disk or plate, not covering more than half the cell wall, containing one pyrenoid. Vegetative reproduction by the breaking up of the filament into individual cells, which may be considered as akinetes; asexual reproduction by biciliate zoospores without stigma, formed singly in a cell, escaping by a small hole in the wall, and germinating without forming a holdfast.

Species of *Stichoccocus* occur in fresh water, rarely in salt or brackish water, and also in moist places not under water. The smaller species of *Ulothrix*, with chromatophore of irregular shape, are not easily distinguished from species of *Stichococcus;* but the biciliate spore of the latter, the absence of a basal cell, and the tendency of the filaments to break up into individual cells, seem to justify keeping it as a separate genus.

KEY TO THE SPECIES OF STICHOCOCCUS.

| | |
|---|---|
| 1. Cells cylindrical. | 2. |
| 1. Cells swollen. | 4. |
| 2. Plant of moist places, not submerged. | 1. *S. bacillaris.* |
| 2. Aquatic. | 3. |
| 3. Marine. | 3. *S. marinus.* |
| 3. Fresh water. | 6. |
| 4. Cells usually over 5 μ diam. | 4. *S. subtilis.* |
| 4. Cells usually under 5 μ diam. | 5. |
| 5. Cells 3-3.5 μ diam., 1-10 diam. long. | 2. *S. scopulinus.* |
| 5. Cells 2.5-3 μ diam., 1-4 diam. long. | 1. *S. bacillaris f. confervoideus.* |
| 6. Plant of moist places, not submerged. | 5. *S. flaccidus.* |
| 6. Fresh water plants, submerged. | 7. |
| 7. Unbranched; filaments readily breaking up. | 6. *S. fluitans.* |
| 7. With rhizoidal branches; not readily breaking up. | 7. *S. rivularis.* |

1. S. BACILLARIS Nägeli, 1848, p. 77, Pl. IV.G., fig. 1; Hazen, 1902, p. 160, Pl. XXII, fig. 1; P. B.-A., No. 1024. Filaments pale green, 2.5-3 μ diam., cylindrical, of 2-24 cells, very readily separating; cells 1-4 diam. long; chromatophore elliptical, thin and pale. Fig. 69. On damp ground, rocks, and on flower-pots in greenhouses. Nova Scotia, N. H., Mass., N. Y., Kansas, N. C., Cal. *Europe.*

Forma CONFERVOIDEUS Hazen, 1902, p. 160, Pl. XXII, figs. 2 and 3. Submerged form; filaments longer, not so readily breaking up. Found among other algae, in rather quiet water, forming crisped or floccose masses. Mass. to N. J.

2. S. SCOPULINUS Hazen, 1902, p. 161, Pl. XXII, figs. 4-6. Filaments forming long, bright green, lubricous masses; cells cylindrical, 3-3.5 μ diam., 1-10 diam. long; wall very thin, chromatophore pale, slender; pyrenoid indistinct.

Slightly larger than S. *bacillaris* forma *confervoidea*, and with longer cells; at the original locality, near New York city, the only station yet recorded, it formed long skeins on dripping rocks; when collected it soon breaks up, or produces abundant zoospores.

3. S. MARINUS (Wille) Hazen, 1902, p. 161, Pl. XXI, figs. 8 and 9; *Ulothrix variabilis* var. *marina* Wille, P. B.-A., No. 615. Filaments dark green; cells cylindrical, 5-6 μ diam., cells 1-2 diam. long; chromatophore a roundish or oblong plate; pyrenoid indistinct. Me., R. I., Conn., Cal. *Northern Europe.*

The only marine species; much more slender than any of our marine species of *Ulothrix*, which are the only plants for which it could be mistaken.

4. S. SUBTILIS (Kütz.) Klercker, 1896, p. 103; Hazen, 1902, p. 162, Pl. XXI, figs. 10-13; *Ulothrix subtilis* Wolle, 1887, p. 135, Pl. CXVIII, figs. 9 and 10, in part; P. B.-A., No. 614. Forming extensive, bright green, lubricous masses; filaments long, cylindrical, 5-6.5 $\mu$ diam., rarely 8 $\mu$; cells 1-3 diam. long; wall thin, chromatophore elliptical, with a small pyrenoid; filaments showing little tendency to break up. Greenland, Me., Vt. to Pa., Cal. *Europe.*

Very common in spring, especially where water is running over rocks; also in watering-troughs and in pools; less common at other seasons.

5. S. FLACCIDUS (Kütz.) Gay, 1891, p. 79, Pl. XI, figs. 101-106; Hazen, 1902, p. 164, Pl. XXI, figs. 14-17; P. B.-A., Nos. 116, 1222; *Ulothrix flaccida* Wolle, 1887, p. 137, Pl. CXVIII, figs. 27-28. Filaments rather short, forming floccose or interwoven masses; cells 6-9.5 $\mu$ diam., somewhat swollen, ¼-1 diam. long, occasionally up to 2 diam.; cell wall fairly thick; chromatophore broad, with a large pyrenoid. On wet rocks and soil, and on the bark of trees. Mass., N. Y., Cal., and probably generally distributed. *Europe.*

Only slightly larger than *S. subtilis*, but with cells usually shorter, distinctly swollen, and with a thicker wall; a plant of moist places rather than submerged.

6. S. FLUITANS Gay, 1893, p. CLXXIV, fig. 1; P. B.-A., No. 759; Hazen, 1902, p. 165, Pl. XXII, figs. 7-9. Filaments yellowish green, crisped and interwoven, sometimes geniculate, with a strong tendency to break up, 6.5-9 $\mu$ diam., cells 1-3 diam. long; chromatophore large and thick, nearly concealing the inconspicuous pyrenoid. Mass., N. J. *Europe.*

In the two American localities this species occurs on smooth rocks swept by rapid water from a cascade; the filaments are unaffected by the current, but when removed to quiet water break up into individual cells in a very short time.

7. S. RIVULARIS (Kütz.) Hazen, 1902, p. 166, Pl. XXII, fig. 10-13; *Ulothrix rivularis* Wolle, 1887, p. 136, Pl. CXVIII, figs. 6-8, 29-33. Forming bright green tufts; filaments somewhat geniculate but not easily breaking up, 8-11 $\mu$ diam., of few cells; giving out hooked rhizoidal branches; cells 1-2 diam. long, somewhat swollen; chromatophore orbicular to rhom-

boidal, sharply marked, pyrenoid large. On rock or earth in rapid streams. N. H., Conn. *Europe.*

Of about the same size as *S. fluitans*, but with filaments more distinctly geniculate, cells less easily separable, and especially characterized by the rhizoidal branches.

### 6. MICROSPORA Thuret, 1850, p. 221.

Filaments simple, usually unattached and with no special basal cell; chromatophore a granular sheet covering the cell wall more or less completely, sometimes with perforations, without pyrenoids but with scattered starch granules. Cell wall composed of laminae, so arranged that when the filaments break up for the escape of zoospores, the pieces remain in the shape of cylinders open at both ends, with a cross wall near the middle, the so-called "H section." Asexual reproduction by 2- or 4-ciliate zoospores, 1 or 2 in a cell; also by smaller 2-ciliate zoospores, formed several in a cell; both kinds germinating directly; whether the smaller kind may also act as gametes is uncertain. Aplanospores and akinetes also formed.

A widely distributed genus of fresh water algae, formerly included in *Conferva*, and in some respects allied to the Heterokontae, but on the whole nearer to the Ulotrichaceae, by the form of the chromatophore and the chemical nature of the cell contents, as well as by the form of the spores. These characters, however, are of little use except in the study of fresh material.

KEY TO THE SPECIES OF MICROSPORA.

| | |
|---|---|
| 1. Cells thick-walled. | 2. |
| 1. Cells thin-walled. | 5. |
| 2. Cells less than 15 μ diam. | 4. *M. pachyderma.* |
| 2. Cells 16 μ diam. or more. | 3. |
| 3. Cells distinctly swollen. | 3. *M. Loefgrenii.* |
| 3. Cells cylindrical or nearly so. | 4. |
| 4. Cells 20 μ diam., 1-2½ diam. long. | 5. *M. Wittrockii.* |
| 4. Cells 21-25 μ diam., 1-2 diam. long. | 2. *M. amoena.* |
| 4. Cells 28-33 μ diam., 1-2 diam. long. | 1. *M. crassior.* |
| 5. Cells 11 μ diam. or more. | 6. |
| 5. Cells 10 μ diam. or less. | 7. |
| 6. Cells 11-14 μ diam. | 7. *M. Willeana.* |
| 6. Cells 14-17 μ diam. | 6. *M. floccosa.* |
| 7. Cells 5-7 μ diam. | 10. *M. quadrata.* |
| 7. Cells 7-9.5 μ diam. | 8. |
| 8. Cells cylindrical. | 8. *M. stagnorum.* |
| 8. Cells slightly constricted. | 9. *M. tumidula.* |

1. M. CRASSIOR (Hansg.) Hazen, 1902, p. 169, Pl. XXIII, fig. 2; P. B.-A., No. 1070; *M. amoena* forma *crassior* Wille, 1899, p. 149. Filaments long, dark green, nearly cylindrical, 28-33 μ diam., cells 1-1.6 diam. long, with wall 2.5-3 μ thick; lamellate structure usually distinct; chromatophore dense, covering the whole cell wall and hiding the large nucleus.

The largest species of the genus, the nearest species, *M. amoena*, being considerably smaller, with thinner walls and relatively shorter cells. It forms thick tangled masses in rapid brooks, from May to October. Mass. to N. Y. *Europe.*

2. M. AMOENA (Kütz.) Rabenhorst, 1868, p. 321; P. B.-A., No. 19b as *Ulothrix zonata*, No. 616; Hazen, 1902, p. 170, Pl. XXIII, fig. 1; *Conferva amoena* Wolle, 1887, p. 140, Pl. CXXI, figs 1-5. Filaments long, dark or bright green, nearly cylindrical, 21-25 μ diam.; cells 1-2 diam. long, with wall about 2 μ thick; chromatophore dense, covering the whole cell wall, and hiding the quite large nucleus. In rapid brooks, forming more or less tangled, often quite long masses, April to July. Mass. to N. J. *Europe.*

3. M. LOEFGRENII (Nordst.) Lagerheim, 1887a, p. 417; Hazen, 1902, p. 171, Pl. XXIII, figs. 3 and 4; Wittr. and Nordst., Alg. Exsicc., No. 17. Filaments long, 16-20 μ diam., cells distinctly swollen, 1-2 diam. long, wall about 2.5 μ thick; chromatophore dense, covering the whole cell wall, concealing the nucleus. N. Y., Mass. *Europe, So. America.*

Smaller than *M. amoena*, and with distinctly swollen cells; but otherwise of the same character as that species and *M. crassior.*

4. M. PACHYDERMA (Wille) Lagerheim, 1887a, p. 415; *Conferva pachyderma* Wille, 1881, p. 13, Pl. IX, figs. 28-35. Filaments 8-14 μ diam., cells 1½-3 diam. long, wall up to 3 μ thick; akinetes rounded-quadrate to ellipsoid, not larger than the vegetative cells. Greenland. *Europe.*

5. M. WITTROCKII (Wille) Lagerheim, 1887a, p. 417; Hazen, 1902, p. 172, Pl. XXIII, figs. 5-7; Wittr. and Nordst., Alg. Exsicc., No. 422. Filaments long, silky, light green, perfectly cylindrical, about 20 μ diam.; cells 1-2½ diam. long, wall about 1.5 μ thick, not distinctly lamellate; chromatophore thin, often perforated, or not occupying the full length of the cell, the large nucleus usually quite distinct. Vermont, Mass., N. Y. *Europe.*

A more delicate plant than any of the preceding species and apparently common in early spring, often in company with *M. stagnorum.*

6. M. FLOCCOSA (Vauch.) Thuret, 1850, p. 222, Pl. XVII, figs. 4-7; Hazen, 1902, p. 173, Pl. XXIV, figs. 1-4; P. B.-A., No. 864. *Conferva floccosa* Wolle, 1887, p. 140, Pl. CXX, figs. 21-25. Filaments bright or yellowish green, cylindrical or very nearly so, 14-17 (rarely 18) $\mu$ diam.; cells 1-2½ diam. long, with thin walls; chromatophore pale green, often perforated or in net form; akinetes 18-22 $\mu$ diam., sphaeroidal, cuboidal or subcylindrical. Fig. 68. Mass. to N. J., Vancouver I. *Europe.*

A very common spring plant, forming loose floccose masses in slow streams and quiet waters.

7. M. WILLEANA Lagerheim in De Toni, 1889, p. 228; Hazen, 1902, p. 175, Pl. XXIV, figs. 5-7; P. B.-A., Nos. 619, 1326. Filaments cylindrical, light green, 11-14 $\mu$ diam.; cells ½-1½ (rarely 2) diam. long, wall thin; chromatophore variable, but usually denser than in *M. floccosa*; akinetes 14-16.5 $\mu$ diam., spherical to subcylindrical. Mass. to N. J., Alaska, Cal. *Europe.*

Occurring in the same localities as *M. floccosa*, and much resembling the latter, but with somewhat smaller filaments and decidedly smaller akinetes.

8. M. STAGNORUM (Kütz.) Lagerheim, 1887 a, p. 417; Hazen, 1902, p. 176, Pl. XXIV, figs. 12-13; P. B.-A., No. 618. Filaments cylindrical, 7.5-9.5 (usually 8) $\mu$ diam., cells 1-3 diam. long, wall thin; chromatophore not dense, and often occupying only the middle part of the cell. Greenland, Maine to N. J. *Europe, So. America.*

A common species of early spring, but occurring also in summer and autumn, often in company with other species of *Microspora* or *Ulothrix*.

9. M. TUMIDULA Hazen, 1902, p. 177, Pl. XXIV, figs. 8-11; P. B.-A., Nos. 1025, 1277. Filaments with distinct constrictions at the dissepiments, 6.7-9.5 (usually 7.5) $\mu$ diam.; cells 1-2 diam. long; chromatophore rather dense, nearly or quite covering the cell wall; akinetes 8-11 $\mu$ diam., spherical or flattened. Greenland, Mass., to N. J., also at Banff, Canada.

Forming dull green skeins or floccose masses in brooks and pools; much like *M. stagnorum*, from which it is distinguished by the distinctly contracted dissepiments and the more uniform chromatophore.

10. M. QUADRATA Hazen, 1902, p. 178, Pl. XXIV, figs. 14 and 15; P. B.-A., No. 1276. Filaments light green, perfectly cylindrical, 5.5-7 $\mu$ diam.; cells ½-1 diam. long, with very thin

wall; chromatophore a fine even coating over all the cell wall, often including the dissepiments. Vermont and Mass. to N. Y.

Forming light green floccose masses, in still or slow water; has been collected from May to October, which would seem to indicate less of a spring plant than most species of *Microspora*. Its very fine filaments with short cells distinguish it quite clearly from our other species.

## Family 2. ULVACEAE.

Membranaceous, plane, or tubular fronds; cells uninucleate, with disk-shape chromatophore and one pyrenoid; asexual reproduction by 4-ciliate zoospores (sometimes biciliate?); sexual reproduction by biciliate gametes.

The membrane is in the form of a tube, a sac, or a flat expansion; in the latter case it may consist of one or two layers of cells; in the simplest forms there may be merely two rows of cells side by side, or in some parts of the frond, only a single series of cells. Spores and gametes may be formed in any cell of the frond except the lowest cells, which may send down rhizoidal prolongations, uniting to form a stipe.

Of world-wide distribution; marine, rarely fresh water plants; usually gregarious, often growing in great quantities. They are specially plants of the litoral zone, occasionally extending down for a short distance into the sublitoral.

### Key to the Genera of Ulvaceae.

1. Frond tubular, rarely of one or two series of cells. 2.
1. Frond tubular only in the early stages, if ever. 3.
 2. Frond gelatinous; cells in loosely united longitudinal series. 2. Ilea.
 2. Not specially gelatinous; membrane parenchymatous. 1. Enteromorpha.
3. Minute; adherent by the entire lower surface. 5. Protoderma.
3. Larger; adherent only at the base. 4.
 4. Frond of a single layer of cells. 3. Monostroma.
 4. Frond of two layers of cells. 4. Ulva.

### 1. Enteromorpha Link, 1820, p. 5.

Frond originating in a single series of cells, which by repeated division form a tubular frond, the membrane of which consists of a single layer of cells; in some of the simpler species the tubular stage is not reached, and the frond in the adult state consists of two or a few series of cells, united without any interior space. All the cells of the frond, except the lowest, capable of producing zoospores or gametes, which are discharged through an opening in the cell wall.

A large genus, connected with *Ulva* by *E. linza*, in which the tube is compressed, and the membranes united in the median part; on the other hand, *Monostroma groenlandicum* is hardly to be distinguished from some of the simple filiform species of *Enteromorpha*. *E. intestinalis* is found the whole world over, and other species are very widely distributed. They are found not only in the sea, but about salt springs and salt mines; they abound in brackish water, and are occasionally found in quite fresh water.

At places where the salinity of the water is subject to much change, very perplexing forms occur; specimens collected near the salt mines at Syracuse, N. Y., show in the same frond characters of *E. compressa*, *E. crinita*, and *E. marginata*. It is impossible to say what is the normal form; the specimens must be considered as teratological. Specimens from Great Salt Lake, Utah, also show abnormal forms.

KEY TO THE SPECIES OF ENTEROMORPHA.

1. Frond flat, the membranes free at the margins, but united between. 19. *E. linza*.
1. Frond of one to a few series of cells, not tubular. 2.
1. Frond tubular. 3.
  2. Frond simple. 1. *E. percursa*.
  2. Frond branched. 2. *E. cruciata*.
3. Cells not arranged in longitudinal series except in the very youngest parts. 4.
3. Cells more or less in longitudinal series, usually in the greater part of the frond. 9.
  4. Cells of the new generation in twos, threes and fours, in the wall of the mother cell. 16. *E. fascia*.
  4. Mother cell wall not persisting after division. 5.
5. Frond with short, spine-like ramuli, in addition to branches. 8. *E. acanthophora*.
5. Frond with more or less plentiful branches. 6.
5. Frond simple or with a few proliferations. 7.
  6. Frond with flattened rachis branching from the margin. 17. *E. micrococca* var. *subsalsa*.
  6. Frond filiform; branches with contracted base, expanding upwards. 10. *E. compressa*.

7. Cells 10-16 $\mu$ diam.; fronds usually inflated and constricted; often of large size. 18. *E. intestinalis.*
7. Cells 4-8 $\mu$ diam.; fronds usually short. 8.
  8. Membrane 8-10 $\mu$ thick; cells 5-7 $\mu$ diam. 11. *E. minima.*
  8. Membrane 15-20 $\mu$ thick; cells 4-5 $\mu$ diam. 17. *E. micrococca.*
9. Fronds simple, inflated and flexuous. 15. *E. flexuosa.*
9. Fronds simple or with occasional proliferations; not inflated. 10.
9. Fronds regularly branched. 11.
  10. Frond narrowly linear, strongly compressed. 13. *E. marginata.*
  10. Frond filiform, 2-8 cells wide, tubular only in the widest parts; branches two cells wide. 3. *E. torta.*
  10. Frond filiform, tubular, of uniform diameter; of numerous series of squarish cells. 14. *E. prolifera* var. *tubulosa.*
11. Frond beset with numerous thorn-like branches. 12. *E. salina* var. *polyclados.*
11. Branches proliferous, similar to main filaments. 14. *E. prolifera.*
11. Branches of successive orders, tapering from base to apex. 12.
  12. Chromatophore filling cell. 13.
  12. Chromatophore not filling cell, giving a net-like appearance. 14.
13. Ultimate ramuli short, spine-like, not monosiphonous. 9. *E. ramulosa.*
13. Ultimate ramuli of a single series of cells. 6. *E. crinita.*
13. Ultimate ramuli polysiphonous, of a few symmetrically placed series of cells. 7. *E. erecta.*
  14. Ultimate ramuli of a single series of cells. 4. *E. plumosa.*
  14. Ultimate ramuli not of a single series of cells. 5. *E. clathrata.*

1. E. PERCURSA (Ag.) J. G. Agardh, 1842, p. 15; P. B.-A., Nos. 469, 968; *Tetranema percursum* Areschoug, 1846, p. 192, Pl. II.A. Frond filiform, in the earliest state of one row, afterwards of two rows of cells, placed symmetrically side by side; cells 10-15 $\mu$ wide, from once to twice as long. Greenland to N. J.; Alaska to Cal. *Europe.*

A common species, forming masses in upper tide pools, and in ditches in marshes, etc. It often grows in company with other species, but is easily distinguished on microscopic examination by the double row of cells, usually in exact symmetry, side by side. The small chromatophores occupy only part of the cell room, giving the same net-like appearance found in *E. clathrata*.

2. E. CRUCIATA Collins, 1896, p. 3; 1903, p. 27, Pl. XLIII, fig. 1; P. B.-A., No. 222. Frond filiform, branching, mostly of a single series of cells, but at the points of branching often of two or more series; branches issuing at right angles or nearly so, usually opposite but sometimes alternate or secund, simple, usually short, tapering; monosiphonous portions 20-30 $\mu$ diameter; cells about as long as broad, cell wall thick; in the irregular masses, where several branches issue near together, the cells are rounded and sometimes reach a diameter of 50 $\mu$.

This plant is very different from other species of *Enteromorpha*, the nearest being *E. percursa;* but *E. cruciata* has nothing of the symmetry and uniformity that especially characterize *E. percursa*. The monosiphonous parts with few and short branches remind one somewhat of *Rhizoclonium*, but the branches are often of many cells, and wherever several branches issue near the same point, an irregular mass of cells is formed. It was found in a lagoon at Eagle Island, Penobscot Bay, Maine, connecting with the sea only at exceptionally high tides, in floating masses in company with *Cladophora expansa*, *Lyngbya*, etc., in July, 1894, and is not known elsewhere.

3. E. TORTA (Mert.) Reinbold, 1893, p. 201; P. B.-A., No. 223. Frond filiform, compressed, simple or with occasional long proliferous branches, which usually consist of only two rows of cells; cells rectangular, always in longitudinal and mostly in cross series. Me., Barbados. *Europe.*

A very slender species, the main filaments only 2-8 cells wide, and only in the wider forms showing any open space within. The branches are few, at wide angles, and are seldom over two cells wide. They resemble somewhat the fronds of *E. percursa*, but the cells in the latter are more symmetrically arranged; and *E. percursa* is always simple and never has over two rows of cells, as do most of the older parts of this plant.

4. E. PLUMOSA Kützing, 1843, p. 300, Pl. XX, fig. 1; *E. Hopkirkii* Harvey, 1849-51, Pl. CCLXIII; 1858, p. 58; P. B.-A., No. 463; *Ulva Hopkirkii* Farlow, 1881, p. 44. Frond filiform, cylindrical or somewhat compressed, very slender and delicate, much and repeatedly branched, the branches tapering and ending in a single series of cells; cells about 8 $\mu$ wide in the monosiphonous part, below about $12 \times 20$ $\mu$, with

quite small chromatophores; always in longitudinal and often in transverse series. Me. to W. I. *Europe.*

One of the most attractive of our *Enteromorphas* both in habit and microscopically. There are other species which occasionally have short monosiphonous branches, but in *E. plumosa* nearly every young branch terminates in a monosiphonous series of considerable extent. Common in northern New England, growing largely on *Cladophora glaucescens* and on rocks and shells in rock pools; also in quiet bays.

5. E. CLATHRATA (Roth) Greville, 1830, p. 181; P. B.-A., No. LXXVIII; *Ulva clathrata* Farlow, 1881, p. 44. Frond filiform, cylindrical or compressed, much branched in all directions, the branches tapering from base to summit, but not ending in a single series of cells; cells rectangular, usually longer than broad, always in longitudinal series, the chromatophore noticeably smaller than the cell. Me. to W. I.; Alaska.
*Europe, Tasmania, New Zealand.*

A species of warm quiet waters, where it often forms great floating masses; it differs from most other species in having a real system of branching of various orders; also in the chromatophore smaller than the cells. From *E. plumosa*, which agrees with it in these particulars, it differs by the absence of monosiphonous ramuli. It is common at some points in southern Mass., and probably along the coast to the south; but so many forms have been included under this name in older records, that few localities are certain. It is not common north of Cape Cod. *Ulva clathrata* var. *Rothiana* forma *prostrata* Farlow, 1881, p. 44, P. B.-A., No. 459, seems nearer to *E. prolifera.*

6. E. CRINITA (Roth) J. G. Agardh, 1882, p. 144; P. B.-A., Nos. 460, 965, 1325. Frond filiform, cylindrical or compressed, much and repeatedly branched, the branches tapering, the smallest usually of a single series of quite short cells; cells almost always in longitudinal series, often rounded, quite or nearly filled by the chromatophore. Me. to N. J.; Gulf of Mexico, Alaska to Cal. *Europe.*

In habit this common marine species resembles *E. clathrata*, but the latter lacks the short-celled monosiphonous ramuli; monosiphonous ramuli are found in *E. plumosa*, but the net-like cells of the latter are quite distinct from the cells of *E. crinita*, which resemble those of *E. prolifera*, though somewhat smaller.

The material distributed as P. B.-A., No. 1325, was from a station once connected from the sea, but cut off for several years, the water becoming quite fresh. The *Enteromorpha* grew in company with species of *Oedogonium*, *Spirogyra*, and other fresh water genera, and was as abundant as ever, the only noticeable change being a greater development of the monosiphonous part in proportion to the rest.

7. E. ERECTA (Lyng.) J. G. Agardh, 1882, p. 152; P. B.-A., No. 461. Frond filiform, with numerous long, usually erect branches, more slender than the main filament; the ultimate ramuli of varying length, polysiphonous, the cells being symmetrically arranged in successive segments, similar to those of *Polysiphonia*; cells in the main stem and branches in longitudinal and usually in transverse series. Fig. 70. Me. to W. I. *Europe.*

The most distinctive character of this species is found in the polysiphonous ramuli; in habit it is not unlike *E. crinita*, but the cells of *E. erecta* are usually more symmetrically arranged in the older parts of the frond, and more rectangular. It is not uncommon as a plant of exposed shores.

8. E. ACANTHOPHORA Kützing, 1849, p. 479; 1856, p. 12, Pl. XXXIV, fig. 1; P. B.-A., No. 515. Frond more or less proliferously branched, the branches usually somewhat enlarged upwards, beset with numerous short, spine-like ramuli, with broad base and acute tip; cells 6-8 $\mu$ diam., roundish angular, showing no longitudinal arrangement except indistinctly at the tips of the ramuli; marine and fresh water. Cal., at shore, and in mountains up to 300 meters. *So. America*, *New Zealand.*

Somewhat resembles *E. ramulosa*, but the cells are much smaller, with hardly any indication of longitudinal arrangement; the substance is less firm, and the color is lighter. The fronds seem to collapse irregularly in drying. The spine-like ramuli vary in abundance, sometimes almost covering the frond; the regular branches are not very numerous, and seem quite distinct from the ramuli.

9. E. RAMULOSA (Eng. Bot.) Hooker, 1833, p. 315; Harvey, 1849-51, Pl. CCXLV; *Ulva clathrata* var. *ramulosa* Farlow, 1881, p. 44. Frond tubular, rather stiff, much branched; branches with short, spine-like ramuli; cells rather rounded, showing longitudinal series only in the ultimate divisions. Mass. to W. I. *Europe*, *New Zealand*, *Australia.*

A coarse species, readily recognized by its habit. It appears to be not uncommon on the southern part of the Atlantic coast, but rare in New England. The color is usually a rather deep or dark green; the main branches are quite long, and are everywhere beset with short, tapering ramuli; the cells are rounded, almost entirely occupied by the chromatophore; without any definite arrangement, except in the ramuli.

10. E. COMPRESSA (L.) Greville, 1830, p. 180, Pl. XVIII. Frond tubular, more or less compressed, sometimes constricted, varying much in dimensions; branches usually simple, cylindrical or expanding above, in either case narrowed at the base, similar in appearance to the main stem; cells in no definite order; membrane rather thin. Greenland to N. J.; Alaska to Cal. *Europe, So. America, Tasmania.*

A variable species, but now understood in a narrower sense than formerly, and including only forms with branches contracted at the base, with cells 10-15 $\mu$ diam., arranged in no definite order, and with membrane not thickened.

Forma SUBSIMPLEX J. G. Agardh, 1882, p. 137; P. B.-A., No. 964. Frond hardly branched, of uniform diameter. Me. *Europe.*

11. E. MINIMA Nägeli in Kützing, 1849, p. 482; 1856, p. 16, Pl. XLIII, fig. 3; P. B.-A., Nos. 468, 912. Frond 1-10 cm. long, 1-5 mm. broad, simple or slightly proliferous, soft and delicate, membrane 8-10 $\mu$ thick, cells angular, 5-7 $\mu$ diam., arranged in no definite order. Greenland to Conn.; Alaska to Mexico. *Europe, So. Pacific.*

A small species, resembling *E. compressa*, but smaller in dimensions of fronds and size of cells. It is probably common, but is easily overlooked among the larger and better known species of the genus. The extreme thinness of the frond gives it a very soft and delicate feeling to the touch, which is the best character by which to recognize it when growing. It seems to grow mostly in the lower half of the litoral zone.

Forma RIVULARIS Collins, P. B.-A., No. XXVI. Color pale, fronds to half a meter in length, substance more delicate than in the type. These differences are probably due to its place of growth, running fresh water. Alaska.

Forma GLACIALIS Kjellman, 1877, p. 50; P. B.-A., No. 1183. Frond 9-13 $\mu$ thick; cells 5-8 $\mu$ diam.; forming a dense coating on rocks covered only at high tide, and at other times wet with water from melting ice. Greenland; Mass.

The habitat given with the description is that of the original arctic locality; the Mass. specimens agree with the Greenland plant, though growing in summer, free from glacial conditions.

12. E. SALINA Kützing, 1845, p. 247; 1856, p. 13, Pl. XXXVI, fig. 1; P. B.-A., No. 659. Frond filiform, tubular, with a few branches, which are sometimes opposite, of two or more rows of cells, or in the youngest of a single series; cells quadrangular, 14-16 μ square, or slightly longer than broad, in longitudinal series throughout; membrane thickened on both sides. Fla., Louisiana. *Europe*.

The slender fronds with relatively large cells in longitudinal series distinguish this species with tolerable distinctness from any others within our limits.

Var. POLYCLADOS Kützing, 1845, p. 248; *E. polyclados* Kützing, 1856, p. 13, Pl. XXXVI, fig. 2. Filaments beset with more or less numerous short, horizontal, spine-like ramuli. Florida.

13. E. MARGINATA J. G. Agardh, 1842, p. 16; Kützing, 1856, p. 15, Pl. XLI, fig. 1; P. B.-A., No. 466. Frond filiform, compressed, simple or with a few proliferous branches; cells 4-8 μ diam., squarish, arranged in longitudinal series, very distinctly in the two or three rows at each side, less so on the middle portion. Me. to N. J.; Great Salt Lake, Utah; Cal. *Europe*.

A small species and apparently not common, occuring mostly on stems and roots of *Spartina*, etc. The color is usually quite a deep green; the fronds are comparatively narrow, seldom over 15-20 cells wide, and the width continues quite uniform throughout a filament, the margin being straight and even. Usually the fronds are simple, but occasionally one finds a few proliferous branches.

14. E. PROLIFERA (Fl. Dan.) J. G. Agardh, 1882, p. 129, Pl. IV, figs. 103 and 104; P. B.-A., Nos. 470, 610, 913. Frond up to several meters long and 2 cm. diameter, tubular or compressed, with more or less abundant proliferous branches, which are usually simple, but sometimes also proliferous; branches varying much in length and diameter; cells 10-12 μ, in the younger parts always arranged in longitudinal series, which become less distinct in the older parts; membrane 15-18

$\mu$ thick, not much exceeding the dimensions of the cells in cross section. Greenland to W. I.; Alaska to Cal. *Europe.*

A common species, formerly included in *E. compressa or E. intestinalis*, to the former of which it is most allied, but from which it differs in the longitudinally seriate cells, very manifest in the younger portions, and disappearing only in the quite old parts. In habit it is very variable, from slender, slightly branched forms, only a few cm. long, to richly and repeatedly branched fronds; branches sometimes long and slender, sometimes short and very densely set, sometimes long and short intermingled quite without order. It appears to prefer somewhat sheltered localities where it is not left bare for any considerable time at low tide. It is found in fresh water in several stations in the western states, as well as about salt springs.

Var. **arctica** (J. Ag.) nov. comb.; *E. arctica* J. G. Agardh, 1882, p. 124, Pl. IV, figs. 100-102. Cells smaller and rounded, membrane 20-30 $\mu$ thick, cells 10-14 $\mu$ in cross section, usually longer than broad, sometimes double their breadth. Greenland. *Spitzbergen.*

Var. TRABECULATA Rosenvinge, 1893, p. 961, fig. 55. More slender than the type, with long, capillary branches; the central cavity traversed by transverse and oblique "trabeculae." Greenland.

Var. TUBULOSA (Kütz.) Reinbold, 1889, p. 117; P. B.-A., No. 471. *E. tubulosa* Kützing, 1856, p. 11, Pl. XXXII, fig. 2. Slender, slightly branched, of nearly uniform diameter throughout. In ditches in marshes. Mass.; Great Salt Lake, Utah; reported from Barbados. *Europe.*

15. E. FLEXUOSA (Wulf.) J. G. Agardh, 1882, p. 126; P. B.-A., No. 462. Frond cylindrical, tubular, simple, tapering to a filiform stipe below, above inflated, flexuous and intestine-like; cells $6\text{-}8 \times 8\text{-}12$ $\mu$, roundish polygonal, in longitudinal series; membrane somewhat thickened on the inside; chromatophore filling the thick-walled cell. Fla., Southern Cal. *Warmer waters generally.*

This is a southern species, and on our Florida shores appears to take the place of *E. intestinalis* in the north. From the latter it differs in having somewhat smaller cells, arranged in regular series; also somewhat more delicate membrane. From *E. compressa* it is also distinguished by the arrangement of the cells, and its habit is dissimilar; from both these species it differs in having a thicker wall between the cells.

16. E. FASCIA Postels and Ruprecht, 1840, p. 21; Wittr. and Nordst., Alg. Exsicc., No. 1052. Frond elongate, tubular-compressed, from a slender stipe; sparingly branched; cells 4-6×6-8 $\mu$, roundish angular, in no apparent order, often containing 2-4 daughter cells. Behring Sea.

In the form of the frond not unlike *E. intestinalis*, but with a different arrangement of cells, somewhat recalling *Ilea fulvescens*. The latter, however, is much softer and more gelatinous, and the cells are arranged in longitudinal series, and more symmetrical in all respects. The characteristic arrangement of cells is not always distinct, and in its absence the species is distinguished from *E. intestinalis* chiefly by the smaller cells. Can hardly be considered a well established species.

17. E. MICROCOCCA Kützing, 1856, p. 11, Pl. XXX, fig. 2; P. B.-A., No. 66. Fronds 1-5 cm. long, 1-5 mm. wide, tubular or compressed, simple or slightly proliferous, much curled and twisted; cells angular, 4-5 $\mu$ diam., in no definite order; thickness of membrane, 15-20 $\mu$. Greenland to Mass.; Alaska to Mexico. *Europe.*

The smallness of its cells distinguishes it from all our species but *E. minima*, in which the dimensions are only slightly larger; but the latter species has a very thin and delicate membrane, while in *E. micrococca* it is relatively quite thick, the thickening being specially pronounced on the inner side; this gives it a coarser feeling to the touch than *E. minima*. Its favorite habitat on the New England coast appears to be on the surface of shaded, steep or vertical cliffs, especially where the flow or drip of fresh water keeps it continually moist.

Forma BULLOSA Collins, P. B.-A., No. 1067. Fronds large, irregularly inflated, to 5 cm. diam. Habit of *E. intestinalis* forma *maxima*, but structure of *E. micrococca*. Cal.

Forma SUBSALSA Kjellman, 1883, p. 292, Pl. XXXI, figs. 1-3; P. B.-A., Nos. 467, 1068. Rachis flattened, with numerous patent branches from the edges; much twisted and contorted, color dark green; growing in lagoons and marshes. Greenland, Mass., Wash. *Europe.*

18. E. INTESTINALIS (L.) Greville, 1830, p. 179; J. G. Agardh, 1882, p. 131, Pl. IV, fig. 109; Harvey, 1846-51, Pl. CLIV; P. B.-A., No. 464; *Ulva Enteromorpha* var. *intestinalis*

Farlow, 1881, p. 43. Frond simple or having at the base a few branches similar to the main frond, or occasionally a few proliferations above; length varying from a few centimeters to several meters; diameter from 1-5 cm.; at first attached by a short, cylindrical stipe, but soon detached and floating; cylindrical or expanding above, more or less inflated, often much crisped and contorted, and irregularly and strongly constricted; cells 10-16 $\mu$ diam., in no regular order; thickness of membrane varying from 50 $\mu$ below to 20 $\mu$ above; cells in cross section from 12 to 30 $\mu$.

A common and exceedingly variable species, occurring throughout our range except on the southern Atlantic coast, where *E. flexuosa* appears to take its place; also in forma *tenuis* in fresh water. There are many intermediate forms that connect it with *E. compressa*, but in its typical form it is distinguished by the internally thickened membrane, and by the intestinal appearance, which is indicated by both its generic and its specific names. It is especially a plant of quiet waters, where it sometimes attains enormous dimensions.

*Europe, Brazil, Japan.*

Among the many forms of this species that have been described, the following have been recognized in America: —

Forma CYLINDRACEA J. G. Agardh, 1882, p. 131; P. B.-A., No. 465. Frond long and slender, of uniform diameter; usually floating unattached. Mass. to Conn., Alaska.

Forma CLAVATA J. G. Agardh, 1882, p. 131; P. B.-A., No. 966. Frond attached, clavate from a filiform stipe, usually more or less contorted. N. S. to Conn.; Alaska to Cal.; in fresh water, alt. 200 meters, Cal.

Forma MAXIMA J. G. Agardh, 1882, p. 132; P. B.-A., No. 1182. Floating, unattached; inflated and bullate. Me. to N. J.; Alaska.

Forma TENUIS Collins, 1903, p. 23; *E. intestinalis* Tilden, Amer. Algae, No. 125. Frond attached, clavate from a tapering stipe; membrane thin and delicate, not thickened within. In size and shape of cells and habit of frond, like forma *clavata* of salt water; the difference in the character of the membrane may be due to the peculiar station, artesian running water. So. Dakota.*

* This may be the same as *E. intestinalis* var. *crispa* Kützing, 1849, p. 478; but the description of the latter variety is insufficient to determine; "Phycomate majori inflato undulato-crispo. In aqua dulci."

19. E. LINZA (L.) J. G. Agardh, 1882, p. 134, Pl. IV, figs. 110-112; P. B.-A., Nos. 16, 967; *Ulva linza* Harvey, 1846-51, Pl. XXXIX; 1858, p. 59; *U. enteromorpha* var. *lanceolata* Farlow, 1881, p. 43. Frond lanceolate or linear-lanceolate, simple, 1-5 dm. long, 1-20 cm. broad; stipe short, hollow; upper part of the frond flat, the membranes grown together as in *Ulva*, except at the edges, where they remain free. Me. to W. I.; Alaska to Cal. *Europe*, *So. America*, *Tasmania*.

The forms of this species are divided by J. G. Agardh under forma *crispata*, with edges much crisped and folded, and forma *lanceolata*, edges even or plicate, not crisped. In one or the other of these forms the species seems common on the whole coast of the U. S.; whether extending farther south is not certain. It grows on stones, woodwork and other algae, usually in places seldom or never left bare by the tide. The smaller forms look like forms of *E. intestinalis*, but in the latter the frond, though often collapsed, is tubular throughout; in *E. linza* the two membranes adhere, except at the edges, where there is a narrow open space, around which the cells are arranged, in cross section nearly in a circle.

2. ILEA Fries, 1825, p. 336.

Frond filamentous, hollow, gelatinous, the cells mostly in twos and fours, enclosed within the wall of the mother cell, and arranged in distinct longitudinal series, the series loosely connected laterally.

Only one species.

I. FULVESCENS (Ag.) J. G. Agardh, 1882, p. 115; P. B.-A., No. 264; *Enteromorpha aureola* Kützing, 1856, p. 14, Pl. XL, fig. 3. Characters of the genus. Fig. 71. Me. to N. J.; Alaska. *Europe*, *So. Pacific*.

This plant grows in dense tufts, the filaments usually 5-20 cm. long, the diam. being seldom over 2 mm., but specimens have been found one meter long, 2 cm. diam. The fronds are soft and gelatinous, the color varying from dark green to brownish or yellow. The cells have a distinctive Gloeocapsa-like arrangement, and are in longitudinal series so distinct that by pressure on the cover glass they readily separate, appearing like free filaments of one or two cells wide.

It grows best in places where streams of fresh water empty into the sea, occupying the space between high and low water marks; so that twice each day its medium is changed from sea water to quite fresh water, and back again. It appears to be common from Maine to New Jersey, and is found at salt springs at Sussex, New Brunswick, 20 miles from the sea.

### 5. MONOSTROMA Thuret, 1854, p. 13.

Frond at first a closed tube or sac, which later opens or splits, forming a membranous expansion, of a single layer of cells, except at the base, where it is thickened, and may consist of several layers of elongated cells. Two- or four-ciliate zoospores and biciliate gametes formed in any of the cells of the monostromatic part, issuing through an opening at the surface of the frond.

In some of the species of this genus the saccate form has not been observed, but it probably occurs in all. Its persistence varies much, from *M. latissimum*, in which the frond forms a flat expansion when only two or three mm. high, to *M. groenlandicum*, in which the greater part of the frond continues tubular through its whole life, only the upper part opening at the time of the formation of the spores. Some of the smaller species do not exceed 1 dm. in length; others, like *M. fuscum*, may reach 5 dm. It has representatives in all oceans, and several species inhabit by preference brackish water; one species lives in fresh water exclusively, and some of the marine and brackish species occasionally occur also in fresh water.

KEY TO THE SPECIES OF MONOSTROMA.

1. Frond always tubular. 2.
1. Frond tubular only in an early stage of growth. 3.
   2. Tube filiform. 1. *M. groenlandicum*.
   2. Tube intestine-like, collapsing. 4. *M. arcticum* var. *intestiniforme*.
3. Frond saccate till plant is well developed: then splitting part or all of the way to the base. 4.
3. Frond saccate only in the early stages or not at all. 5.
   4. Segments rather broad, irregularly divided. 2. *M. Grevillei*.
   4. Segments narrowly linear, simple, forked or palmate. 3. *M. Lactuca*.
5. Frond dark to dull green, not adhering to paper. 11. *M. fuscum*.
5. Frond light or bright green, adhering generally to paper. 6.
   6. Mature frond divided into distinct segments. 7.
   6. Frond broadly lanceolate to orbicular, not divided into segments. 8.

7. Segments linear or lanceolate, frond about 6 $\mu$ thick above. 5. *M. pulchrum.*
7. Segments few, broad; frond 25-45 $\mu$ thick; cells close. 4. *M. arcticum.*
7. Segments obovate, frond 18-36 $\mu$ thick; cells not closely set. 7. *M. crepidinum.*
8. Frond not over 30 $\mu$ thick, except near the base. 9.
8. Frond 40-50 $\mu$ thick. 12.
9. Frond not usually much plicate. 10.
9. Frond usually much plicate. 13.
10. Cells arranged in distinct groups of 4. 9. *M. quaternarium.*
10. Cells not in distinct groups of 4. 11.
11. Cells in longitudinal and transverse series. 12. *M. leptodermum.*
11. Cells not in series. 8. *M. latissimum.*
12. Chromatophore in cross section not over 9 $\mu$ high. 6. *M. undulatum.*
12. Chromatophore in cross section about 15 $\mu$ high. 10. *M. orbiculatum.*
13. Frond much lobed, margin distinctly thinner than base. 10. *M. orbiculatum* var. *varium.*
13. Frond not much lobed; thickness nearly uniform. 6. *M. undulatum* var. *Farlowii.*

1. M. GROENLANDICUM J. G. Agardh, 1882, p. 107, Pl. III, figs. 80-83; P. B.-A., No. 13. Frond filiform, tubular, cylindrical, up to 15 cm. long, from a very slender base expanding to 1 mm. diameter; apex broken only at exit of spores. Cells in the lower part of the frond loosely arranged in twos and fours, roundish angular; in the upper part more evenly distributed, more or less closely set. In cross section the membrane is 25-35 $\mu$ thick; the cells radiately elongate, 2-4 times as long as broad; in the younger parts the central cavity is filled with a gelatinous substance, which disappears as the plant becomes older. Spores or gametes formed first at the summit of the frond, and developing successively in lower cells. Greenland to Mass.; Alaska.

This plant has no external resemblance to a *Monostroma*, and was placed in this genus with a mark of doubt by both Farlow and Rosenvinge. It appears like a slender, unbranched *Enteromorpha*, but seems, however, to be in structure more nearly related to *Monostroma*. It occurs from April to June in New England; in July at Newfoundland; and from May to August in Greenland. On the Atlantic coast it grows in rather dense tufts, at the lower limit of the litoral zone, in company with

*Spongomorpha arcta*, *Bangia fusco-purpurea*, *Hormiscia*, etc. In all specimens from the Pacific coast that have been examined, the cells are decidedly smaller than in specimens from the Atlantic; 8-10 $\mu$ diam. in the former, 12-16 $\mu$ diam. in the latter, seen superficially.

2. M. GREVILLEI (Thuret) Wittrock, 1866, p. 57, Pl. IV, fig. 14; Farlow, 1881, p. 41; P. B.-A., No. 15; *Ulva Lactuca* Harvey, 1846-51, Pl. CCXLIII; 1858, p. 60. Frond attached, at first saccate, then opening at the top, and ultimately splitting to the base; soft and delicate, pale green; membrane 15-20 $\mu$ thick, cells quadrate with rounded angles, closely set; in cross section horizontally oval, 12-14 $\mu$ high. Sporiferous cells enlarged, vertically elongate in cross section; cell wall dissolving after emission of spores. Greenland to N. J.; Alaska to Cal. *Europe.*

The saccate form is plain in young plants, and may persist for some time when growing in still water; but at exposed points the frond is soon torn open, and in mature plants all trace of the original shape is lost, wherever growing.

An early spring plant except in Arctic regions, where it continues till August.

Var. VAHLII (J. Ag.) Rosenvinge, 1893, p. 949; *M. Vahlii* J. G. Agardh, 1882, p. 109, Pl. III, figs. 84-89. More slender in form, often cylindrical, retaining its saccate shape longer, and with cells arranged in more or less distinct longitudinal series. An early spring plant. Greenland to Mass.; Alaska.

Var. **lubricum** (Kjellman) nov. comb.; *M. lubricum* Kjellman, 1877a, p. 48, Pl. IV, figs. 8 and 9. Frond up to 15 cm. long, pale or whitish green, delicate, very lubricous and flaccid, of irregular outline, laciniate, plicate, margin often crisped and lacerate; frond 18-22 $\mu$ thick; cells seen superficially circular or rounded angular, often in twos or fours, cell wall thick; in cross section horizontally ovate or oblong, 4.5-8 $\mu$ high. Greenland, Alaska. *Northern Europe.*

This has never been found attached, but always as shapeless floating fronds; with our imperfect knowledge of it, it is probable that it is a form of *M. Grevillei* in which the cells are somewhat shrunken, the membrane much gelatinized.

3. M. LACTUCA (Roth) J. Ag., 1882, p. 102, Pl. III, fig. 90; Areschoug, Alg. Scand. Exsicc., No. 121; P. B.-A., No. 1271. Frond at first an elongate, obconical sac, soon splitting to the base into linear, simple or forked laciniae, usually with

crisped edges; membrane 20-25 μ thick; cells seen superficially parenchymatously united, chromatophore not filling the cell; cells angular, often arranged in twos, threes or fours; in cross section rounded, horizontally elongate, 15-18 μ high. Cell walls persisting after emission of spores. Mass., R. I., Conn.

*Europe.*

A spring plant, nearly allied to *M. Grevillei*, but quite distinct in habit and texture. It has a thicker membrane, which is also firmer and less lubricous. *M. Grevillei* forms at first a globular or obovate sac, splitting into broad segments of indefinite shape; *M. Lactuca* at first is a longer sac, and divides into long, sublinear laciniae, often with a tapering stipe-like base; when these laciniae are simple, the resemblance to *Enteromorpha linza* is striking; when they fork, which is often the case, the resemblance to *Ulva fasciata* is equally marked; there are some fronds with quite distinct palmate division of the laciniae.

4. M. ARCTICUM Wittrock, 1866, p. 44, Pl. II, fig. 8; P. B.-A., No. 910. Frond attached, at first saccate, soon splitting into a few broad laciniae; subradiately plicate, with crisped margin; pale green, becoming yellowish in drying; membrane 25-45 μ thick; cells 4-6 angled, closely set, irregularly placed; in cross section either vertically or horizontally oval, 10-30 μ high. Greenland, Alaska. *Northern Europe.*

A northern species, chiefly distinguished from *M. Grevillei* by the thicker frond, which is saccate only in the earliest stages and afterwards appears as a rather broad membrane, not split up into strips, as is usual in *M. Grevillei*. *M. saccodeum* Kjellman, 1883, p. 296, Pl. XXVIII, figs. 1-10; *M. cylindraceum* Kjellman, 1883, p. 295, Pl. XXX, and *M. angicava* Kjellman, 1883, p. 297, Pl. XXIX, seem to be forms of *M. arcticum*.

Var. **intestiniforme** (Rosenv.) nov. comb.; *M. Grevillei* var. *intestiniforme* Rosenvinge, 1893, p. 953, fig. 52. Frond tubular, to 50 cm. long; membrane 25-50 μ thick; cells rounded, closely set, vertically oval in cross section, 15-20 μ high; usually arranged in more or less distinct series longitudinally. Greenland.

Resembles in habit *M. Grevillei* var. *Vahlii*, but in thickness of membrane and size and shape of cells agrees with *M. arcticum*; it is rather persistently tubular, and except by careful examination of its structure, is liable to be mistaken for *Enteromorpha intestinalis*.

5. M. PULCHRUM Farlow, 1881, p. 41; P. B.-A., No. 658. Frond divided into linear or lanceolate segments with slender base, much crisped at the margin, light green, membrane about 6 $\mu$ thick in the upper part, up to 15 $\mu$ near the base, cells roundish, rather irregular in form.

A beautiful species, extremely delicate, adhering so closely to paper when mounted that it is almost impossible to detach it for examination. It occurs on rocky shores, usually epiphytic on other algae, from April to June. Newfoundland to R. I.

6. M. UNDULATUM Wittrock, 1866, p. 46, Pl. III, fig. 9. Frond membranaceous, soft and flaccid, with strongly undulate margin; 40-50 $\mu$ thick; cells angular, closely set, showing somewhat of an arrangement in twos, threes, and fours; in cross section about 20 $\mu$ high, semicircular or oval; chromatophore not occupying the full height of the cell; not over 10 $\mu$ in the middle. Greenland. *Northern Europe.*

The typical form has a thicker frond than any other species but *M. fuscum*, which is not likely to be mistaken for it, being amply distinct by its color and consistency.

Var. FARLOWII Foslie, 1890, p. 114; P. B.-A., No. 406. Frond similar to the type, but less than 30 $\mu$ thick. Greenland to Mass. *Norway.*

7. M. CREPIDINUM Farlow, 1881, p. 42; P. B.-A., No. 220. Frond delicate, light green, 5-15 cm. long, flabellately orbiculate, when fully developed split nearly or quite to the base, segments obovate; membrane 18-36, rarely 45 $\mu$ thick; cells roundish-angular, when actively dividing forming compact groups of 2, 3, or 4, separated by rather wide spaces. Mass. to N. J.

On woodwork between tide marks, also on rocks; it is usually in rather dense tufts, which have a rich dark green color, though the individual frond is light green. It resembles in habit the European *M. Wittrockii*, but has a thicker frond, with cells more elongate horizontally in cross section. *M. Wittrockii* is more membranaceous in texture, not adhering well to paper.

8. M. LATISSIMUM (Kütz.) Wittrock, 1866, p. 33, Pl. I, fig. 4; P. B.-A., Nos. 14, 1122. Frond at first attached, afterwards floating; thin and soft, glossy, of irregular shape, more or less plicate near the even or undulate margin; membrane 20-25 $\mu$ thick, cells 4-6-cornered or roundish, closely set, without order or more or less distinctly in twos, threes, and fours; in cross section vertically oval or nearly circular, 14-18 $\mu$ high. Me. to Fla.; Alaska to Washington. *Europe, Africa, New Zealand.*

Apparently not uncommon in quiet waters, especially in ditches in marshes, where the water is sometimes brackish rather than salt. At first it is attached to various objects, but soon becomes loosened and floats freely, sometimes in such abundance as to quite fill a ditch from bottom to surface. It appears in spring, and continues, chiefly in the floating state, through the summer. The arrangement of cells varies in plants from the same locality, and even in different parts of the same frond; indeed, the shape of the cells, whether seen from above or in cross section, is liable to vary in any species of *Monostroma*, or in different stages of growth of the individual.

9. M. QUATERNARIUM (Kütz.) Desmazières, Plantes Crypt. de France, Troisème Série, No. 603, 1859; Wittrock, 1866, p. 37, Pl. I, fig. 5; P. B.-A., No. 567; *Ulva quaternaria* Kützing, 1856, p. 6, Pl. XIII, fig. 2. Frond at first attached, soon becoming free, soft and delicate, irregularly lobed and folded, 20-23 $\mu$ thick; cells rounded, when actively dividing set closely in threes and fours within the mother cell wall; in cross section semicircular or oval, 15-17 $\mu$ high. In brackish or fresh water, Washington to Cal.; various fresh water localities throughout the western U. S. *Europe.*

10. M. ORBICULATUM Thuret, 1854, p. 388; Wittrock, 1866, p. 39, Pl. II, fig. 6; Alg. Am. Bor., No. 173. Frond membranaceous, attached by fibrils, or later free; soft and flaccid, sub-orbicular or irregular in outline, often radially plicate, with undulate margin, 30-40 $\mu$ thick; cells angular, varying much in size and arrangement, often irregularly elongate, closely set, but with chromatophore not occupying the whole cell; in cross section vertically oval, 25-30 $\mu$ high. In fresh and brackish water. Bermuda, Cal. *Europe.*

Like other species, this varies much in color, the Bermuda plant being a full green, the California plant quite pale. In the Bermuda specimens the frond is somewhat thinner than the type, and the radical fibrils are strongly developed.

Var. VARIUM Collins, 1909a, p. 26. Frond very much lobed and plicate, forming a rosette-like expansion, attached at the center; frond 50-60 $\mu$ thick in the older part, diminishing to 16 $\mu$ at the margin. On muddy shore near low water mark. So. Mass.

The much divided and very much folded frond is quite different in appearance from the typical *M. orbiculatum*, but no difference can be seen in the form and dimensions of the cells, except that the membrane is thicker in the older parts and thinner in the younger in var. *varium*, than in the type, in which the frond is of nearly uniform thickness.

11. M. FUSCUM (Post. and Rupr.) Wittrock, 1866, p. 53, Pl. IV, fig. 13. Frond membranaceous, at first tubular, soon splitting, dull green, more or less lobed but not divided to the base; membrane 20-35 $\mu$ thick; cells 4-6-angled, very closely set; in cross section quadrate, with only slightly rounded corners; occupying nearly the entire thickness of the frond. Greenland, Alaska. *Northern Europe.*

Under this species are included two forms, which, with the type, pass into each other with no dividing line, while they are sharply marked off from all other species of the genus in nearly every respect. The very young plant is in the form of a closed tube, which soon splits down one side, and spreads out to form a flat membrane; not splitting into several segments, as in the *Grevillei* group. Compared with other species of *Monostroma*, the *fuscum* forms are thick and coarse, blackish when dried, staining the paper on which they are mounted, and not adhering well to it.

Forma BLYTTII (Wittr.) Collins, 1903, p. 12; *M. Blyttii* Wittrock, 1866, p. 49, Pl. III, fig. 11; Farlow, 1881, p. 41; *M. fuscum*, P. B.-A., No. 715. Frond deep green, blackish in drying, 60-70 $\mu$ thick; cells "palisade-form" in cross section. Fig. 72. Greenland to R. I.; Vancouver Island, Washington.

A plant of late autumn and winter in New England, in tide pools and also on pebbles in the sublitoral zone; great quantities are sometimes washed ashore by storms, the stones on which they grew remaining attached to them.

Forma SPLENDENS (Wittr.) Collins, 1903, p. 12; P. B.-A., No. 911; *M. splendens* Wittrock, 1866, p. 50, Pl. III, fig. 12. Frond deep green, glossy, 50-55 $\mu$ thick, more deeply parted than in the other forms; cells similar to those of forma *Blyttii*, or more rounded. Alaska to Vancouver I. *Northern Asia.*

12. M. LEPTODERMUM Kjellman, 1877, p. 52, Pl. I, figs. 23 and 24; P. B.-A., No. 1272; *M. zostericolum* Tilden, Amer. Algae, No. 388. Frond cuneate-obovate or divided into segments of that form; cells squarish, in distinct series, longitudinal and transverse; the former often radiate, the latter concentric; mar-

gin more or less undulate; membrane 7-10 $\mu$ thick, cells quadrate in cross section, 5-8 $\mu$ high. Greenland (?), Mass., Wash. *Arctic Sea*.

This species has the most delicate frond of all the genus, except *M. pulchrum*, and grows in spring below low water mark or in pools. It was founded by Kjellman on specimens found unattached, without basal part; Rosenvinge, 1893, p. 944, identifies with it a plant from Greenland, with a filiform, tubular stipe of varying length. No such stipe has been seen in the specimens from Massachusetts and Washington; hundreds of specimens of all stages of growth have been examined, without finding any indications of a stipe. The structure of our plant agrees with Kjellman's description and figures, and his name is here retained; it may be that the Greenland plant is distinct from that of northern Europe.*

4. ULVA Linnaeus, 1753, p. 1163.

Frond membranaceous, flat, consisting of two layers of cells, in any of which, except those in the thickened base, zoospores or gametes may be formed, issuing through an opening in the surface of the frond. Marine.

KEY TO THE SPECIES OF ULVA.

1. Frond divided into distinct segments. 3. *U. fasciata*.
1. Frond entire or irregularly lobed or laciniate. 2.
   2. Frond minute, triangular or reniform, with distinct stipe. 2. *U. californica*.
   2. Frond ample, at first lanceolate, later of no definite outline. 1. *U. Lactuca*.

1. U. LACTUCA Linnaeus, 1753, p. 1163; Thuret and Bornet, 1878, p. 5, Pls. II, III; *U. Lactuca* var. *Lactuca* Farlow, 1881, p. 43. Frond very variable in shape, at first attached and generally of a lanceolate or ovate-lanceolate form; later of irregular shape, and often detached and floating. The cells usually vertically elongate in cross section; seen from the surface irregularly angular, closely set; thickness of the frond very variable. Fig. 75.

*There have been several reports of *M. thermalis* from interior points of the United States, and in some cases the determination was confirmed by J. G. Agardh. But the latter, 1882, p. 110, expresses considerable doubt as to whether what he understands as *M. thermalis*, is the same as the *Ulva thermalis* of Meneghini, 1837, p. 21. All the American speciexamined, including several in Herb. Farlow, prove to be species of *Enteromorpha*.

A very common plant over the whole world, and extremely variable in form, thickness and color. Two fairly marked types can be distinguished in the species as found with us on both Atlantic and Pacific coasts, connected by innumerable forms.

Var. RIGIDA (Ag.) Le Jolis, 1863, p. 38; Farlow, 1881, p. 42; P. B.-A., No. 407. Frond at first lanceolate or ovate-lanceolate, firm and stiff, with a distinct stipe; later somewhat irregularly divided, and often with numerous perforations of various sizes; cells vertically elongate in cross section.

This is a common form of exposed shores, but occurs also sometimes in quieter waters. In its earlier stages it is distinctly lanceolate in outline, but this form is afterwards lost by irregular growth. It is firm in texture, the color deepening as the plant grows older, finally becoming brownish or blackish; the cells have their greatest length at right angles to the surface of the frond, being sometimes three times as long as wide.

Var. LATISSIMA (L.) DC., 1805, p. 9; P. B.-A., No. LXXVI. Frond irregular in outline, soon becoming detached and passing most of its life in a floating condition; thinner than var. *rigida*, lighter colored, and with cells nearer square in cross section.

This is a common form of creeks and lagoons, where it forms floating sheets, often of several square meters in extent.

Var. MESENTERIFORMIS (Roth) Collins, 1900, p. 45. Frond much contorted and bullate, forming crumpled masses, lying loose on the bottom.

This form is strikingly distinct in appearance, forming much crisped and wrinkled masses, usually of a dark green color, lying on the bottom in creeks and quiet bays. It is so twisted and grown together that only by tearing can even a small piece of it be spread out flat. In cross section the cells are nearer square than those of the type. It is common in marshy pools near Bridgeport, Conn., and will probably be found in similar places. Known elsewhere only in the Baltic.

2. U. CALIFORNICA Wille, P. B.-A., No. 611. Frond 1.5 to 2 cm. long, up to 1.5 cm. wide, triangular or reniform with wavy edge, sometimes with proliferations of a few cells each; passing quickly into a flattened, tapering stipe. The cells of the stipe, which on the inner side form rhizoidal prolongations, are in cross section about quadrate; the cells in the upper part

of the frond are rather irregularly polygonal with rounded corners; no noticeable arrangement in longitudinal series; frond about 30 $\mu$ thick.

A species with minute fronds, with more definite outline than is usual in species of this genus. It is known only from California, where it forms a rather dense coating on rocks near high water mark. Hardly enough is known of this plant to decide whether its position is permanently assured.

3. U. FASCIATA Delile, 1813, p. 153, Pl. LVIII, fig. 5; Harvey, 1858, p. 58; P. B.-A., No. 221. Frond divided into more or less linear segments, margin smooth or undulate; in cross section the two layers of cells separate somewhat at the margin, which is rounded, with a small, open space between the rows. Fla., W. I., Cal. *Warm waters all over the world.*

The structure of the frond is similar to that of *U. Lactuca*, except the margin, which resembles *Enteromorpha linza*; but the shape of the frond, with definite divisions, is quite distinct in the typical form. On the Californian coast, however, it is hard to draw the line between this and *U. Lactuca*, either from the shape of the frond or from its structure. Even in the typical form there is much diversity as to the divisions of the frond; they may be dichotomous or apparently lateral; their width may vary from 5 mm. to 5 cm.; and the frond may reach a length of a meter; the margin may be smooth and even, or much crisped and undulate; in this last it corresponds to forms of *Enteromorpha linza*. Four forms have been distinguished on the Pacific coast, passing into each other more or less.

Forma TAENIATA Setchell, P. B.-A., No. 862. Lobes slender and elongated, crisped and ruffled; prominent teeth on the margins near the base of the frond.

Forma CAESPITOSA Setchell, P. B.-A., No. 809. Divisions numerous, irregular; fronds intricately entangled, forming a dense coating on the rocks.

Forma LOBATA Setchell, P. B.-A., No. 863. Lobes short and broad, seldom crisped or ruffled.

Forma EXPANSA Setchell, P. B.-A., No. LXXVII. Frond ample, of generally orbicular outline, lobes broad or narrow, more or less sinuous, margin much ruffled; frond 60-70 $\mu$ thick, cells somewhat elongate in cross section.

PROTODERMA Kützing, 1843, p. 295.

Frond a minute disk, closely attached to the substratum, formed originally of radiating, branching filaments, which, except at the margin, are united to a sub-parenchymatous layer of one or more cells in thickness; cells with parietal disk-shaped chromatophore and one pyrenoid; asexual reproduction by aplanospores and by biciliate zoospores with red stigma.

The proper position of this genus is quite uncertain; West, 1904, places it in the Pleurococcaceae; Oltmans, 1904, ignores it; it must be placed somewhere, and in the Ulvaceae is as good a place as any. There is no doubt that immature organisms of many kinds have passed under the name of *P. viride*, but *P. marinum* is more distinct.

KEY TO THE SPECIES OF PROTODERMA.

1. Fresh water. 1. *P. viride.*
1. Marine. 2. *P. marinum.*

1. P. VIRIDE Kützing, 1843, p. 295; 1856, p. 6, Pl. XI, fig. 1. Frond pale green, at first circular, later more or less irregular; filaments parenchymatously united in the interior of the disk, free at the margin; cells in the young frond with thin wall, cylindric to cuneate, 3-6 $\mu$ wide, usually 2-3 times as long; in middle of adult frond 6-8, or even 12 $\mu$ wide, 1-2 times as long, spherical, ovoid, or ellipsoid, with thick wall; zoospores globose to ovoid, 3-3.5 $\mu$ diam.; aplanospores globose to ellipsoid, 2-3 $\mu$ diam. Fig. 73. On wood and stones in ponds. Mass., Barbados. *Europe.*

2. P. MARINUM Reinke, 1889, p. 81; P. B.-A., No. LIII. Forming thin coatings of irregular form, composed of angular, parenchymatously united cells, 6-12 $\mu$ wide, irregularly placed, except at the margin, there in rather indistinct radiating series. Me. to Conn. *Europe.*

Common as a thin green film on pebbles in pools and at low water mark, along the New England coast; probably elsewhere.

## Family 3. PRASIOLACEAE.

Filamentous or membranaceous; cells with star-shape chromatophore and one pyrenoid; asexual reproduction by segmentation of the frond, by akinetes and by aplanospores; sexual reproduction unknown. Fresh water or marine.

KEY TO THE GENERA OF PRASIOLACEAE.

1. Frond normally of a single series of cells, occasionally expanding laterally to two or a few series. 1. SCHIZOGONIUM.

1. Frond at first of a single series of cells, soon becoming a membrane. 2. PRASIOLA.

1. Frond at first of a single series of cells, soon becoming a terete multicellular filament. 3. GAYELLA.

### 1. SCHIZOGONIUM Kützing, 1843, p. 245.

Frond normally a filament of a single series of cells, but at times dividing longitudinally, so as to form ribbon-shaped fronds, two or a few cells wide; cells usually shorter than their diameter, with central stellate chromatophore and one pyrenoid; asexual reproduction by akinetes and aplanospores.

Usually terrestrial algae, normally filamentous, occasionally dividing longitudinally, but not forming distinctly foliaceous expansions. Gay, 1891, gives a broader extension to the genus, adding *S. crispum*, which appears here as *Prasiola crispa*. This species produces filamentous fronds which may or may not develope into membranes; it connects the two genera, and it is not easy to decide under which to include it.

KEY TO THE SPECIES OF SCHIZOGONIUM.

1. Uniseriate filaments cylindrical; multiseriate not uncommon. 1. *S. murale*.

1. Uniseriate filaments moniliform or crenulate; longitudinal cell-division in a single cell or in a few successive cells. 2. *S. crenulatum*.

1. S. MURALE Kützing, 1843, p. 246; Gay, 1891, p. 87, Pl. XIII, figs. 122-125. Forming a soft, tomentose stratum, bright or dull green; filaments flexuous, simple or rarely with short, few-celled branches; cells usually 10-14 $\mu$ diam., occasionally a little more or less; often biseriate; rarely pluri-seriate. On moist earth, rocks, trees, etc. N. H., Alaska. *Europe*.

Var. ALPINUM Farlow, P. B.-A., No. 70. Submerged; forming long, loose, floating tufts in mountain brooks. N. H.

2. S. CRENULATUM (Kütz.) Gay, 1888, p. 72; 1891, p. 88, Pl. XIII, fig. 131. Forming a thin stratum, bright or dull green; filaments more or less moniliform or crenulate, rather stiff, entangled, 11-14 $\mu$ diam., occasionally one or a few cells duplicated; cells about as long as broad, more or less swollen at the middle, walls between the cells quite thick. Fig. 76. On moist wood, etc. N. H., Mass. *Europe*.

### 2. PRASIOLA (Ag.) Meneghini, 1838, p. 36.

Fronds membranaceous, monostromatic, attached by short filiform prolongations, by the edge of the membrane, or by a thickened stipe; cells with stellate chromatophore and one pyrenoid, dividing to form groups of fours, these groups forming similar larger groups, the spaces between the groups of various orders constituting narrower or wider spaces, running in definite directions through the frond. Asexual reproduction, 1st, by the breaking off of small portions of the frond, which attach themselves and grow independently; 2d, by akinetes formed from individual cells assuming thick walls: these akinetes may develop either directly into a filament or membrane, or indirectly by aplanospores, several in each akinete; 3d, by aplanospores, formed 4-8 in a cell, by walls in 2 or 3 directions; sexual reproduction unknown.

The species of this genus resemble small forms of *Ulva* or *Monostroma;* most of them are so minute as to be barely noticeable, but some may reach a length of 10 cm. Some species grow in cold mountain streams, but most of them are found in moist places, not immersed; some inhabit by preference quite uncleanly stations; a few species are marine. While there have been reports of the production of zoospores, it is now generally supposed that these reports were based on misapprehensions, and that the reproduction is asexual and non-motile. In the character of the frond, and in the formation of spores, there are quite interesting similiarities between *Prasiola* and *Porphyra.*

KEY TO THE SPECIES OF PRASIOLA.

| | |
|---|---|
| 1. Marine. | 4. *P. borealis.* |
| 1. Fresh water or terrestrial. | 2. |
| 2. Frond with long, stipe-like base. | 3. |
| 2. Stipe short or wanting. | 4. |
| 3. Frond near base of a single series of cells. | 1. *P. calophylla.* |
| 3. Frond always of several series of cells. | 2. *P. fluviatilis.* |
| 4. Terrestrial. | 5. *P. crispa.* |
| 4. In cold mountain streams. | 3. *P. mexicana.* |

1. P. CALOPHYLLA (Spreng.) Meneghini, 1838, p. 36; Jessen, 1848, p. 14, Pl. I, figs. 1-3; P. B.-A., No. 1273. Fronds linear to narrowly cuneate, with truncate apex, many from the same holdfast, seldom over 1 cm. long, 1 mm. wide; cells near the base in a single series, about 10 $\mu$ long by 3-5 $\mu$ broad; farther up in two rows, the number increasing towards the upper part of the frond or as the frond grows older; the series of cells and the intercellular lines nearly parallel throughout; cells near the apex of the frond about 3-5 $\mu$ square; thickness of frond about 15 $\mu$; cells 8-10 $\mu$ high in cross section. Wash., Cal.

*Europe.*

The minute linear fronds with filiform stipe and truncate apex, distinguish this species from others of the genus.

2. P. FLUVIATILIS (Sommerf.) Areschoug in Lagerstedt, 1869, p. 28; Wittr. and Nordst., Alg. Exsicc., No. 1234; *P. Sauteri*, Jessen, 1848, p. 15, Pl. I, figs. 4-9. Fronds cuneate-lanceolate to obovate, to 10 cm. high, 2 cm. wide, apex obtuse, not truncate; cells near the base in a few series, above more numerous; series of cells and intercellular spaces parallel below, more areolate in the upper part; cells 4-6 $\mu$ wide; frond 13-19 $\mu$ thick, cells 8-13 $\mu$ in cross section. Greenland, Alaska. *Europe.*

A plant of cold mountain streams, in general shape somewhat like *P. calophylla*, but larger, with rounded apex, and without monosiphonous stipe except at very early stages.

3. P. MEXICANA J. G. Agardh, 1847, p. 6; Jessen, 1848, p. 19, Pl. I, figs. 17-20; P. B.-A., No. 1186. Frond up to 10 cm. long and wide, of more or less rounded outline, attached by a short, thickened stipe; cells 6-16 $\mu$ diam., rather closely set; asexual reproduction by division of frond, by akinetes more rounded than the vegetative cells, and with slightly thicker wall; and by aplanospores formed 8-16 in a cell, in the upper marginal portion of the frond, from subglobose to oblong, 6-8 $\mu$ wide, up to 14 $\mu$ long. In cold mountain streams, sometimes at very high altitudes. Wyo., Oregon, Colo., Mexico. *So. America.*

In appearance quite like a small *Ulva*; the areolate character is not so conspicuous as in some other species; at the formation of the aplanospores the margin for a greater or less depth becomes softer and of lighter color, very much in the same way as on the formation of the antheridia in *Porphyra*.

4. P. BOREALIS Reed, 1902, p. 160, Pl. XV. Fronds cuneate to obovate, stipitate or sessile, margin crenulate, crisped or entire, soft membranaceous, 33-45 $\mu$ thick, 5-10 mm. high, in tufts of several from one holdfast; cells in distinct tetrads, areolar arrangement manifest; cells 4-9 $\mu$ diam., seen superficially; in cross section oblong or palisade-form, 11-14 $\mu$ high. On rocks near high water mark. Alaska.

The fronds of this species are very generally infested with a fungus, *Guignardia Alaskana* Reed; it has its counterpart in antarctic regions in *Prasiola tesselata* Kütz., infested by *Guignardia Prasiolae* (Winter) Reed.

5. P. CRISPA (Lightf.) Meneghini, 1838, p. 36; Jessen,

1848, p. 18, Pl. I, figs. 10-16; Wolle, 1887, p. 106, Pl. XCI, figs. 25-27; P. B.-A., Nos. 1069, 1184. Frond of indefinite form, rounded, lacerate, or plicate, without stipe, attached to substratum by the edge of the frond or by fine fibrils; usually in dense masses; fronds sometimes as much as 10 cm. high or wide, but usually much smaller; generally 13-16 $\mu$ thick; cells squarish or rectangular, 8-13 $\mu$ diam., in cross section square or slightly higher than wide. Fig. 77. In moist and especially in unclean places. Greenland, Newfoundland, Alaska, Cal.

*Europe.*

The description given above is of the normal adult frond; along with this are generally found very narrow forms, only two or three cells wide, and also forms of a single series of cells; the latter agreeing in every way with what has been known as *Hormidium parietinum* or *H. murale;* these have been distributed as P. B.-A., Nos. 969, 1274; but every gradation can be found between these and the typical *Prasiola* fronds, and there is little doubt that under certain conditions or in certain stages the *Prasiola* develops the *Hormidium* forms. The areolate structure is not so clear in *P. crispa* as in some other species, but it shows distinctly enough in the younger plants, becoming less distinct as the plant grows older.*

3. GAYELLA Rosenvinge, 1893, p. 936.

Frond filiform, simple or very slightly branched, at first of a single series of cells, later dividing longitudinally into many series, but always remaining filiform, not flat; cell structure as in *Prasiola*. Marine.

G. POLYRHIZA Rosenvinge, 1893, p. 937, figs. 45 and 46; P. B.-A., No. 914. Frond at first a simple filament of a single series of disk-shaped cells, 10-12 $\mu$ diam., attached to the substratum by a rhizoidal projection from the lower cell; later attached at various parts of the filament by rhizoidal growths, one or two from a cell; increasing in diameter by growth and division of cells, up to 70 $\mu$ diam.; terete or somewhat irregular in surface, but not flattened; cells with parietal chromatophore and one pyrenoid; in the mature plant showing superficially an arrangement in longitudinal and transverse lines; in cross section an arrangement by 2-4-8-16, etc., in somewhat Gloeocapsa-like form; asexual reproduction by aplanospores, arranged in

**P. Gardneri* Collins, P. B.-A., No. 1185, there placed with some doubt in this genus, seems on further study to belong rather to the blue-green algae.

longitudinal and horizontal series. Figs. 78, 79. Greenland, Alaska.

Börgesen, 1902, p. 482, includes *Gayella* in *Prasiola crispa* as subspecies *marina*. It is certainly hard to draw the line between *Prasiola*, *Schizogonium* and *Gayella* ; but the habit of *Gayella* is so distinct from the other two genera, that until we have definite evidence of the connection, it would seem better to maintain the genus.

## Family 4. CYLINDROCAPSACEAE.

Frond a monosiphonous, rarely partly polysiphonous filament, at first attached, later free, composed of cells with parietal chromatophore and one pyrenoid ; asexual reproduction by zoospores has been reported, but is not fully confirmed ; akinetes as in *Ulothrix ;* sexual reproduction by antheridia and oogonia, 2-4 antheridia formed by division of a vegetative cell, each antheridium producing 2 spindle-shaped, biciliate, yellowish spermatozoids, escaping through an opening in the side wall ; oogonium formed from a swollen vegetative cell, containing one oospore, fertilized by spermatozoids entering by an opening in the wall ; fertilized oospore reddish, development unknown ; the unfertilized oospore may develop parthenogenetically, remaining green, and dividing to form a new filament. Fresh water. Only one genus.

### CYLINDROCAPSA Reinsch, 1867, p. 66.

Characters of the family.

In its vegetative characters *Cylindrocapsa* is nearly related to *Ulothrix*, but in fructification it shows considerable resemblance, and is the only alga having any considerable resemblance, to the Oedogoniaceae.

C. GEMINELLA Wolle, 1887, p. 104, Pl. XCI, figs. 1-17 ; P. B.-A., No. 570. Filaments 14-16 $\mu$ diam. (or more ?) subtorulose, with thick, distinctly lamellate wall ; oospore globose, about 50 $\mu$ diam., lamellate wall about 10-15 $\mu$ thick. In standing water, free or adhering to other algae. Fig. 80. Mass. ; "N. Y. to Florida and westward," Wolle.* *Europe.*

## Family 5. OEDOGONIACEAE.

Fronds aquatic, in one European species terrestrial, consisting

**C. amoena* Wolle, 1887, p. 105, Pl. XCI, figs. 18-23, with filaments cylindrical, 7-12 $\mu$ diam., cells 2-3 diam. long, fructification by zoospores of two sizes, can hardly be recognized from the description ; there is really nothing to indicate that it is a *Cylindrocapsa*.

of simple or branching filaments, of a single series of uninucleate cells; chromatophores generally of many longitudinal bands, with many pyrenoids; cell division by the rupture of a circular ring, which forms the membrane of the new cell. Asexual reproduction by multiciliate zoospores, each produced from the entire contents of a cell, and germinating immediately; also in some cases by akinetes. Sexual reproduction by oogonia and antheridia; oogonia single or seriate, formed by transformation of vegetative cells; opening by a lid or a pore to admit the spermatozoids; when fertilized the oospore assumes a membrane; after a period of rest the oospore produces four zoospores (occasionally fewer or more), which germinate at once. Antheridia either in the same filament with the oogonia or in separate individuals; male plants either of about the same sized cells as the female plants, or much smaller; in the latter case the male plants arise from androspores, similar to zoospores but smaller; spermatozoids produced one or two in an antheridium, smaller than the androspores, but of similar appearance. Fresh water.

The Oedogoniaceae are distinct from all other families, only the very small family of the Cylindrocapsaceae showing any near relationship. There are two genera of world-wide distribution, *Oedogonium* and *Bulbochaete; Oedocladium*, a monotypic genus, is found in Europe.

The vegetative structure is of the simplest, but the mode of cell division is found nowhere else; the reproductive characters are elaborate and varied, and the special variations peculiar to the different species seem to be quite constant. A very thorough study of the family has been made by Hirn, and his monograph is the basis for the following pages; his descriptions have been closely followed, few changes or additions being required for present purposes.

1. OEDOGONIUM Link, 1820, p. 5.

Frond of a single, unbranched series of cells, vegetative cells cylindrical, rarely with constrictions; basal cell with holdfast; terminal cell obtuse, apiculate or produced into a long seta; all cells capable of division; oogonia produced directly by division of a vegetative cell.

In this genus there are more definite characters for distinction of species than in any other of the larger genera of green algae, and these characters are quite constant in each species; abnormal developments are of course to be expected, but they can usually be recognized as such. The chief difficulty lies in the fact that different organs may be distributed over two or three distinct classes of filaments, and it is by no means easy to get all in the same collecting. Add to this the fact that different species frequently grow together, so that it is rather the exception to make a collection all of one species, and it will be seen that it is only too easy to overlook one of the forms of the species under consideration, or to mistake for it a filament of another species.

The peculiarities of the species of *Oedogonium* require a number of special names to be used in the descriptions, and they may be summarized as follows: the antheridia and oogonia may occur on the same filament (monoecious species) or on separate filaments (dioecious); in the latter case the male filaments may be nearly similar to the female (macrandrous species) or very much smaller (nannandrous). In the latter case the male filaments (nannandres, dwarf males) are minute plants of a few cells each, epiphytic on the female filament, usually on the oogonium or on the cell below it (suffultory cell). These dwarf males are produced by the germination of special spores (androspores) produced in androsporangia; the androsporangia are short cells, usually narrower than the vegetative cells of the filaments in which they occur; they are either single or two or more in a series; they occur in the same filament as the oogonia (gynandrosporous species) or in separate filaments (idioandrosporous); when the former they may be directly above the oogonium (epigynous) or a short distance above the oogonium (subepigynous), directly below the oogonium (hypogynous), or a short distance below (subhypogynous). When occurring without any reference to the oogonium they are said to be scattered. The dwarf males may be unicellular, the spermatozoids being produced in the single cell, or pluricellular; in the latter case the antheridium may be produced merely by a partition forming in the originally unicellular male (antheridium interior); or in a cell or in the upper of two or more cells formed at the summit of the male by the typical Oedogonium cell division (antheridium exterior); in this case the part below the antheridium is known as the stipe, and may be one to several celled. An antheridium may produce one or two spermatozoids; in the latter case the spermatozoids may be formed side by side, with a vertical partition (division vertical), or one above the other (division horizontal). The oogonium receives the spermatozoid either by a round opening in the wall (poriferous oogonium), or by the upper part of the oogonium separating from the lower part by a circular division all around the wall (operculate). The pore may be opposite the middle of the spore (pore median), higher up (pore superior), or lower down (pore inferior). In the operculate species the same distinction is indicated by division median, superior or inferior. The membrane of the oospore may consist of one to three layers; in the latter case these are known as the outer membrane or exospore, median membrane or mesospore, and inner membrane or endospore. In the monoecious species the antheridia occupy positions similar to those of the androsporangia in the nannandrous gynandrosporous species, and are similarly known as epigynous, etc. The formation of the spermatozoids is the same as in the nannandrous species.

The subdivision of the genus is largely artificial; the usual division is into monoecious, dioecious macrandrous, and dioecious nannandrous species; but interesting parallelisms may be found between the first and third of these series. There seem to be more species of limited distribution in this genus than in most genera of green algae, but it may be due to imperfect knowledge; certainly some species occur at widely distant stations. Undoubtedly many species not yet recorded for North America will be found here when more attention is paid to them. They are all species of quiet or slowly flowing water, and may be found at any time, except when the water is frozen over.

KEY TO THE SPECIES OF OEDOGONIUM.

| | | |
|---|---|---|
| 1. | Macrandrous. | 2. |
| 1. | Nannandrous. | 45. |
| 2. | Oogonium opening by a pore. | 3. |
| 2. | Oogonium opening by a lid. | 33. |
| 3. | Spores globose. | 4. |
| 3. | Spores ellipsoid. | 17. |
| 4. | Pore median. | 5. |
| 4. | Pore supramedian. | 7. |
| 4. | Pore superior. | 11. |

| | |
|---|---|
| 5. Membrane of oospore smooth. | 6. |
| 5. Membrane of oospore pitted. | 3. *Oe. Magnusii.* |
| 5. Membrane of oospore spinous. | 4. *Oe. suecicum.* |
| 6. Monoecious. | 1. *Oe. cryptoporum.* |
| 6. Dioecious. | 2. *Oe. rufescens.* |
| 7. Pore slightly above the middle. | 8. |
| 7. Pore almost superior. | 10. |
| 8. Monoecious. | 9. |
| 8. Dioecious. | 7. *Oe. cardiacum.* |
| 9. Oogonia subglobose or subdepressed-globose. | 5. *Oe. obsoletum.* |
| 9. Oogonia subglobose or subellipsoid-globose. | 6. *Oe. plusiosporum.* |
| 10. Monoecious. | 9. *Oe. varians.* |
| 10. Dioecious. | 8. *Oe. franklinianum.* |
| 11. Oogonia manifestly swollen. | 12. |
| 11. Oogonia little if any swollen. | 15. |
| 12. Membrane of oospore smooth. | 13. |
| 12. Membrane of oospore pitted. | 13. *Oe. foveolatum.* |
| 13. Monoecious. | 14. |
| 13. Dioecious. | 12. *Oe. plagiostomum.* |
| 14. Vegetative cells 12-17 $\mu$ diam. | 10. *Oe. fragile.* |
| 14. Vegetative cells 20-30 $\mu$ diam. | 11. *Oe. Vaucherii.* |
| 15. Monoecious. | 14. *Oe. geniculatum.* |
| 15. Dioecious. | 16. |
| 16. Oogonia $\frac{1}{3}$ to $\frac{1}{2}$ wider than vegetative cells. | 15. *Oe. capilliforme.* |
| 16. Oogonia scarcely wider than vegetative cells. | 16. *Oe. capillare.* |
| 17. Oogonia manifestly swollen. | 18. |
| 17. Oogonia little if any swollen. | 27. |
| 18. Membrane of oospore smooth. | 19. |
| 18. Membrane of oospore ribbed or pitted. | 21. |
| 19. Monoecious. | 20. |
| 19. Dioecious. | 19. *Oe. rivulare.* |
| 20. Division of antheridial cell vertical. | 17. *Oe. upsaliense.* |
| 20. Division of antheridial cell horizontal. | 18. *Oe. Richterianum.* |
| 21. Membrane of oospore ribbed. | 22. |
| 21. Membrane of oospore areolate or pitted. | 25. |
| 22. Ribs continuous and entire. | 23. |
| 22. Ribs not continuous and entire. | 24. |
| 23. Monoecious. | 20. *Oe. paludosum.* |
| 23. Dioecious. | 21. *Oe. Boscii.* |
| 24. Ribs composed of elongate dots. | 22. *Oe. margaritiferum.* |
| 24. Ribs distinctly dentate. | 23. *Oe. crenulato-costatum.* |
| 25. Membrane of oospore areolate. | 23. *Oe. crenulato-costatum var. aureum.* |
| 25. Membrane of oospore pitted. | 26. |

26. Oogonia 38-48 $\mu$ diam. 25. *Oe. punctatum.*
26. Oogonia 70-83 $\mu$ diam. 24. *Oe. taphrosporum.*
27. Membrane of oospore smooth. 28.
27. Membrane of oospore pitted. 70. *Oe. giganteum.*
28. Monoecious. 26. *Oe. martinicense.*
28. Dioecious. 29.
29. Oogonia 63-75 $\mu$ diam. 27. *Oe. Landsboroughii.*
29. Oogonia 65 $\mu$ diam. or less. 30.
30. Vegetative cells 3-9 diam. long. 31.
30. Vegetative cells 1¾-3 diam. long. 31. *Oe. mexicanum.*
31. Oogonia oboviform. 28. *Oe. oboviforme.*
31. Oogonia suboboviform to oboviform-ellipsoid. 32.
32. Male plants stouter than female. 29. *Oe. pachyandrium.*
32. Male plants more slender than female. 30. *Oe. grande.*
33. Oospores globose. 34.
33. Oospores ellipsoid. 42.
34. Division of oogonium median. 35.
34. Division of oogonium superior. 36.
35. Cells with spiral markings. 32. *Oe. punctato-striatum.*
35. Cells with walls plain. 33. *Oe. Howardii.*
36. Monoecious. 37.
36. Dioecious. 38. *Oe. Pringsheimii.*
37. Vegetative cells with three nodulose swellings. 41. *Oe. nodulosum.*
37. Vegetative cells cylindrical. 38.
38. Oogonium when mature pyriform or subpyriform. 39.
38. Oogonium when mature oboviform-globose to subglobose. 40.
39. Oogonium 26-30 $\mu$ diam. 34. *Oe. Pithophorae.*
39. Oogonium 40-45 $\mu$ diam. 71. *Oe. pyriforme.*
40. Oogonia distinctly swollen. 41.
40. Oogonia little swollen. 37. *Oe. autumnale.*
41. Vegetative cells 15 $\mu$ diam. or less. 35. *Oe. crispum.*
41. Vegetative cells 16 $\mu$ diam. or more. 36. *Oe. obesum.*
42. Membrane of oospore smooth. 43.
42. Membrane of oospore ribbed. 42. *Oe. nobile.*
43. Oogonia oblong-ellipsoid or ellipsoid. 44.
43. Oogonia pyriform. 72. *Oe. sanctae thomae.*
44. Vegetative cells 3-7 $\mu$ diam. 40. *Oe. gracillimum.*
44. Vegetative cells 10-18 $\mu$ diam. 39. *Oe. Ahlstrandii.*
45. Dwarf males pluricellular. 46.
45. Dwarf males unicellular. 66.
46. Antheridium exterior. 47.
46. Antheridium interior. 64.
47. Oogonium opening by a pore. 48.
47. Oogonium opening by a lid. 62.

| | | |
|---|---|---|
| 48. | Oospore globose. | 49. |
| 48. | Oospore ellipsoid. | 58. |
| 49. | Pore median or slightly above. | 50. |
| 49. | Pore superior. | 53. |
| 49. | Pore inferior. | 52. *Oe. Huntii.* |
| 50. | Membrane of oospore smooth. | 51. |
| 50. | Membrane of oospore spinous. | 52. |
| 51. | Oogonium 30-37 μ diam. | 43. *Oe. Braunii.* |
| 51. | Oogonium 49-53 μ diam. | 44. *Oe. flavescens.* |
| 52. | Oogonium subdepressed-globose. | 45. *Oe. pungens.* |
| 52. | Oogonium subglobose to ellipsoid. | 46. *Oe. echinospermum.* |
| 53. | Membrane of oospore smooth. | 54. |
| 53. | Membrane of oospore spinous. | 55. |
| 54. | Oogonia solitary. | 47. *Oe. irregulare.* |
| 54. | Oogonia usually seriate. | 59. *Oe. multisporum.* |
| 55. | Spines without order. | 56. |
| 55. | Spines arranged spirally. | 57. |
| 56. | Spines scanty ; oogonia subglobose. | 48. *Oe. armigerum.* |
| 56. | Spines dense ; oogonia depressed-globose. | 49. *Oe. echinatum.* |
| 57. | Oogonium 51-64 μ diam. ; veg. cells 15-35 μ diam. | 50. *Oe. stellatum.* |
| 57. | Oogonium 63-78 μ diam. ; veg. cells 32-59 μ diam. | 51. *Oe. Donnellii.* |
| 58. | Pore median or slightly higher. | 59. |
| 58. | Pore superior. | 60. |
| 59. | Membrane of oospore smooth. | 53. *Oe. sexangulare.* |
| 59. | Membrane of oospore spinous. | 54. *Oe. Hystrix.* |
| 60. | Membrane of oospore smooth. | 61. |
| 60. | Membrane of oospore ribbed. | 57. *Oe. Wolleanum.* |
| 60. | Membrane of oospore pitted. | 58. *Oe. concatenatum.* |
| 61. | Suffultory cell not swollen. | 55. *Oe. crassiusculum.* |
| 61. | Suffultory cell swollen. | 56. *Oe. Borisianum.* |
| 62. | Oospore globose. | 60. *Oe. macrandrium.* |
| 62. | Oospore ellipsoid. | 63. |
| 63. | Oogonia 14-23 μ diam. | 61. *Oe. longatum.* |
| 63. | Oogonia 30-56 μ diam. | 62. *Oe. acrosporum.* |
| 64. | Oogonium opening by a pore. | 65. |
| 64. | Oogonium opening by a lid. | 64. *Oe. undulatum.* |
| 65. | Membrane of oospore smooth. | 73. *Oe. cataractum.* |
| 65. | Membrane of oospore ribbed. | 63. *Oe. cyathigerum.* |
| 66. | Oospore globose. | 67. |
| 66. | Oospore ellipsoid. | 69. *Oe. pluviale.* |
| 67. | Division of oogonium medium. | 68. |
| 67. | Division of oogonium inferior. | 68. *Oe. platygynum.* |
| 68. | Oospore nearly or quite filling the oogonium. | 69. |
| 68. | Ooospore not nearly filling the oogonium. | 67. *Oe. Areschougii.* |

| | |
|---|---|
| 69. Oogonium 20-27 $\mu$ diam. | 65. *Oe. Rothii.* |
| 69. Oogonium 30-38 $\mu$ diam. | 70. |
| 70. Oospore depressed. | 66. *Oe. decipiens.* |
| 70. Oospore globose. | 74. *Oe. londinense.* |

MACRANDRIA, PORIFERA, GLOBOSPORA.

1. OE. CRYPTOPORUM var. VULGARE Wittrock, 1874, p. 7; Hirn, 1900, p. 73, Pl. I, fig. 2; Wolle, 1887, p. 70, Pl. LXXIV, figs. 1-2; P. B.-A., No. 1525. Monoecious; oogonia single or more usually 2-5 seriate, oboviform-globose or depressed-globose, opening by a median pore; oospore depressed-globose, nearly filling the oogonium; membrane smooth; antheridia 1-4 celled, subepigynous, hypogynous or scattered; spermatozoid single.

| | | |
|---|---|---|
| veg. cell, | 5-8 $\mu$ diam., | 3-6 diam. long. |
| oogonia, | 18-23 $\mu$ " | 18-26 $\mu$ long. |
| oospores, | 16-23 $\mu$ " | 15-19 $\mu$ " |
| anth. cell, | 5-7 $\mu$ " | 9-12 $\mu$ " |

Mass., Pa., N. J., sec. Wolle. *Europe, Australia.*

The type, with somewhat larger measurements in every direction, oogonia single, antheridia 1-7 celled, occurs in northern Europe, but has not been found here.

2. OE. RUFESCENS Wittrock, 1870, p. 134; Wolle, 1887, p. 89, Pl. LXXXI, figs. 16 and 17; Hirn, 1900, p. 76, Pl. I, fig. 4; P. B.-A., No. 521. Monoecious; oogonia single or 2-3, oboviform- or depressed-oboviform-globose, pore median; oospore globose or depressed-globose, filling the oogonium or nearly so, membrane smooth; male plants slightly more slender than the female; antheridia up to 12-celled; spermatozoid single.

| | | |
|---|---|---|
| veg. cell, female, | 8-10 $\mu$ diam., | 4-7 diam. long. |
| veg. cell, male, | 7-9 $\mu$ " | 4-6 " " |
| oog., | 22-24 $\mu$ " | 22-30 $\mu$ long. |
| oos., | 21-23 $\mu$ " | 17-22 $\mu$ " |
| anth. cell, | 6-8 $\mu$ " | 8-12 $\mu$ " |

R. I., Conn. *Europe.*

Subsp. LUNDELLII (Wittr.) Hirn, 1900, p. 77, Pl. I, fig. 6; P. B.-A., No. 1428. Oogonia and oospores more depressed, the former subdepressed- or depressed-globose; vegetative cells somewhat shorter and in comparison with the oogonia somewhat stouter than in the type; oogonia solitary or two.

| | | |
|---|---|---|
| veg. cell, female, | t9-12 $\mu$ diam., | 3-4½ diam. long. |
| veg. cell, male, | 8-10 $\mu$ " | 3-4 " " |
| oog., | 22-25 $\mu$ " | 23-27 $\mu$ long. |
| oos., | 19-23 $\mu$ " | 15-22 $\mu$ " |
| anth. cell, | 7-8 $\mu$ " | 6-12 $\mu$ " |

Maine, Cal. *Europe.*

3. OE. MAGNUSII Wittrock, 1874, p. 38; Hirn, 1900, p. 81, Pl. II, fig. 14; Wittr. and Nordst., Alg. Exsicc., No. 109. Dioecious; oogonia single, rarely 2, depressed-globose, pore median; oospore same form as oogonium and fully filling it, with triple membrane; median pitted, others smooth; antheridia up to 8-celled; spermatozoid single.

| | | |
|---|---|---|
| veg. cell, | 7-10 $\mu$ diam., | 1½-4 diam. long. |
| oog., | 24-27 $\mu$ " | 21-26 $\mu$ long. |
| oos., | 22-25 $\mu$ " | 18-23 $\mu$ " |
| anth. cell, | 8-10 $\mu$ " | 5-11 $\mu$ " |

Mass. *Northern Europe.*

4. OE. SUECICUM Wittrock, 1872a, p. 5; Hirn, 1900, p. 82, Pl. II, fig. 15. Dioecious; oogonia single, subglobose, rarely ellipsoid-globose, pore median; oospore globose, nearly filling the oogonium; epispore with subulate spines; male plants about the same size as the female or slightly smaller; antheridium 2-4-?-celled, generally in the upper part of the filament; spermatozoid single?; basal cell elongate, terminal cell obtuse.

| | | |
|---|---|---|
| veg. cell, | 9-14 $\mu$ diam., | 3-7 diam. long. |
| oog., | 32-38 $\mu$ " | 18-26 $\mu$ long. |
| oos. with spines, | 30-37 $\mu$ " | 30-37 $\mu$ " |
| anth. cell, | 10-12 $\mu$ " | 9-12 $\mu$ " |

Mass. *Europe, Australia.*

The only macrandrous dioecious species with spinous oospores.

5. OE. OBSOLETUM Wittrock, 1874, p. 9; Wolle, 1887, p. 71, Pl. LXXIV, fig. 3, Pl. LXXVI, figs. 6 and 7; Hirn, 1900, p. 83, Pl. II, fig. 16. Monoecious; oogonia single, subglobose or depressed globose, pore slightly above the middle; oospore globose or depressed-globose, not quite filling the oogonium, membrane smooth; antheridia 1-3 celled, subepigynous; spermatozoid single.

| | | |
|---|---|---|
| veg. cell, | 9-15 $\mu$ diam., | 3-5 diam. long. |
| oog., | 34-39 $\mu$ " | 34-43 $\mu$ long. |
| oos., | 30-34 $\mu$ " | 28-32 $\mu$ " |
| anth. cell, | 8-9 $\mu$ " | 12-16 $\mu$ " |

Pa. *Sweden.*

This species and the following are included only on account of Wolle's reference, which is quoted as to this species with a ? by Hirn. The two following species closely resemble it. *Oe. obsoletum* and *Oe. plusiosporum* are monoecious; *Oe. cardiacum* is dioecious, and of somewhat larger dimensions. *Oe. obsoletum* generally has longer vegetative cells than the others, and oogonia shorter than their diameter, while *Oe. plusiosporum* has a stouter aspect, and almost ellipsoidal oogonia. *Oe. cardiacum* has two spermatozoids in each antheridial cell, the others one spermatozoid only.

6. OE. PLUSIOSPORUM Wittrock, 1874, p. 11; Wolle, 1887, p. 72, Pl. LXXIV, figs. 20 and 21; Hirn, 1900, p. 84, Pl. II, fig. 17. Monoecious; oogonia single, subglobose or ellipsoid-globose, pore slightly above the middle; oospore globose or nearly so, not quite filling the oogonium, membrane smooth; antheridia up to 6-celled, subepigynous, subhypogynous, or scattered; spermatozoid single; terminal cell obtuse.

| | | |
|---|---|---|
| veg. cell, | 12-19 μ diam., | 2-4 diam. long. |
| oog., | 34-45 μ " | 35-50 μ long. |
| oos., | 30-39 μ " | 30-39 μ " |
| anth. cell, | 12-14 μ " | 8-12 μ " |

Pa., N. J., Cal. *Northern Europe.*

7. OE. CARDIACUM (Hass.) Wittrock, 1870, p. 135; Hirn, 1900, p. 85, Pl. III, fig. 19. Dioecious; oogonia single, very rarely 2, subglobose or subcordiform-globose, pore slightly above the middle; oospore globose, not filling the oogonium, membrane smooth; male plants slightly more slender than the female; antheridia up to 10-celled, spermatozoids binate, division horizontal; basal cell elongate, terminal cell obtuse.

| | | |
|---|---|---|
| veg. cell, female, | 18-30 μ diam., | 3-7 diam. long. |
| veg. cell, male, | 15-25 μ " | 3-7 " " |
| oog., | 48-70 μ " | 58-78 μ long. |
| oos., | 42-60 μ " | 42-60 μ " |
| anth. cell, | 15-21 μ " | 10-14 μ " |

Pa., Ontario. *Europe, Africa, So. America.*

The range in dimensions is considerable; in most cases the plants approach the lower limit, only rarely the upper.

Var. CARBONICUM Wittrock, in Wittr. and Nordst., Alg. Exsicc., No. 504; Hirn, 1900, p. 87, Pl. IV, fig. 22, is reported from Iowa by Wolle, 1887, p. 90, Pl. LXXXII, figs. 14 and 15. It has oogonia not uncommonly double, oboviform or globose-oboviform, pore higher than in the type, oospore the same form as the oogonium, and not quite filling it.

8. OE. FRANKLINIANUM Wittrock, in Wittr. and Nordst., Alg. Exsicc., No. 309; Wolle, 1887, p. 89, Pl. LXXXII, figs. 7-9; Hirn, 1900, p. 88, Pl. II, fig. 18. Dioecious; oogonia single (very rarely 2), subglobose (or sub-ellipsoid-globose), pore superior; oospore globose, almost filling the oogonium, membrane smooth; male plant rather more slender than the female; antheridia 1-3-celled; spermatozoids 2, division horizontal.

| | | |
|---|---|---|
| veg. cell, female, | 9-12 μ diam., | 3-8 diam. long. |
| veg. cell, male, | 8-10 μ " | 3-9 " " |
| oog., | 26-31 μ " | 29-41 μ long. |
| oos., | 24-30 μ " | 24-30 μ " |
| anth. cell, | 8-9 μ " | 5-7 μ " |

N. J., Pa. *So. America.*

Resembling *Oe. cardiacum*, but a more slender plant, and with pore higher up on the oogonium.

9. OE. VARIANS Wittrock and Lund in Wittrock, 1874, p. 11; Hirn, 1900, p. 89, Pl. IV, fig. 23; *Oe. polymorphum* Wolle, 1887, p. 73, Pl. LXXIV, figs. 16-19. Monoecious; oogonia single, very rarely 2, depressed- or subdepressed-pyriform-globose, pore nearly superior; oospore globose, not filling the oogonium, membrane smooth; antheridia to 9-celled, scattered; spermatozoids binate, division horizontal; basal cell elongate, terminal cell obtuse.

| | | |
|---|---|---|
| veg. cell, | 12-16 μ diam., | 3-9 diam. long. |
| oog., | 35-50 μ " | 34-55 μ long. |
| oos., | 31-41 μ " | 30-41 μ " |
| anth. cell, | 11-15 μ " | 5-7 μ " |

N. J. *Europe.*

Characterized specially by the high position of the pore, and by the antheridia, in series of several, irregularly placed among the vegetative cells.

10. OE. FRAGILE Wittrock, 1870, p. 120; Wolle, 1887, p. 71, Pl. LXXIV, figs. 4-6; Hirn, 1900, p. 96, Pl. V, fig. 33; P. B.-A., No. 1477. Monoecious; oogonia single, globose or subobovi-form-globose, pore superior; oospore globose, filling the oogonium, membrane smooth; antheridia 1-3-celled, hypogynous or subepigynous; spermatozoids binate, division horizontal; basal cell elongate. Fig. 81.

| | | |
|---|---|---|
| veg. cell, | 12-17 μ diam., | 4-7 diam. long. |
| oog., | 42-50 μ " | 44-55 μ long. |
| oos., | 39-46 μ " | 39-46 μ " |
| anth. cell, | 12-15 μ " | 10-12 μ " |

Mass., Pa. *Europe.*

Beside the type, Hirn notes and figures, Pl. VI, fig. 34, a form, not named, from Massachusetts, with dimensions of cells, oogonia and oospores about 3 μ more than the type; the antheridia may be up to 6 in a series, occurring irregularly in the filament.

11. OE. VAUCHERII (LeCl.) A. Braun, 1855a, p. 40, Pl. II, fig. 13; Hirn, 1900, p. 97, Pl. VI, fig. 36; Wittr. and Nordst.,

Alg. Exsicc., No. 20. Monoecious; oogonia single, oboviform or suboboviform-globose, pore superior; oospore globose or subglobose, not quite filling the oogonium, membrane smooth, usually thick; antheridium up to 4-celled, subepigynous or hypogynous; spermatozoids binate, division horizontal; basal cell elongate.

| | | |
|---|---|---|
| veg. cell, | 20-30 $\mu$ diam., | 1½-4 diam. long. |
| oog., | 40-55 $\mu$ " | 45-65 $\mu$ long. |
| oos., | 35-50 $\mu$ " | 35-52 $\mu$ " |
| anth. cell, | 17-24 $\mu$ " | 6-11 $\mu$ " |

Mass. *Europe, Asia.*

Resembling *Oe. fragile*, but with vegetative cells stouter and shorter, while the oogonia are of about the same size.

12. OE. PLAGIOSTOMUM var. GRACILIUS Wittrock, 1878, p. 142; Hirn, 1900, p. 101, Pl. VI, fig. 40. Dioecious; oogonia single, oboviform-globose, pore superior; oospore globose or sub-globose, about filling the oogonium, with thick, smooth membrane; male plant about the same size as the female; antheridia 1-5-celled, often alternating with vegetative cells; basal cell elongate.

| | | |
|---|---|---|
| veg. cell, female, | 20-25 $\mu$ diam., | 2-3½ diam. long. |
| veg. cell, male, | 20-23 $\mu$ " | 2-4 " " |
| oog., | 36-42 $\mu$ " | 46-57 $\mu$ long. |
| oos., | 34-39 $\mu$ " | 36-44 $\mu$ " |
| anth. cell, | 19-22 $\mu$ " | 7-10 $\mu$ " |

N. Y., Mexico.

The type, with vegetative cells about 2 $\mu$ thicker, oogonia and oospores 7 $\mu$ more diam., occurs in Europe; the dimensions given above are for Mexican specimens; those from Ithaca, N. Y., have cells a little more slender.

13. OE. FOVEOLATUM Wittrock, 1878, p. 133; Hirn, 1900, p. 106, Pl. VII, fig. 46. Monoecious; oogonia single, rarely 2, oboviform- or subellipsoid-globose, pore superior; oospore globose or subellipsoid-globose, filling or not quite filling the oogonium, membrane double, outer with net-like markings, inner smooth; antheridia 1-7-celled, hypogynous, subepigynous, or scattered; spermatozoids binate, division horizontal; basal cell elongate, terminal cell obtuse.

| | | |
|---|---|---|
| veg. cell, | 14-23 $\mu$ diam., | 2½-5 diam. long. |
| oog., | 37-49 $\mu$ " | 38-57 $\mu$ long. |
| oos., | 33-46 $\mu$ " | 34-48 $\mu$ " |
| anth. cell, | 15-19 $\mu$ " | 8-12 $\mu$ " |

St. Thomas. *So. America.*

The net-like marking of the spores is found in some other species, but the only one with which there is any danger of mistake is *Oe. scrobiculatum*, which can be distinguished by being dioecious, and having ellipsoid spores.

14. OE. GENICULATUM Hirn, 1898, p. 28; 1900, p. 106, Pl. VIII, fig. 48; P. B.-A., No. 411. Monoecious; oogonia single, slightly swollen, oboviform or oboviform-globose, pore superior; oospore not filling the oogonium, globose or sub-depressed-globose, sometimes appearing subquadrangular; membrane thick, smooth; antheridia 1-5-celled, subepigynous, subhypogynous or scattered, often alternating with vegetative cells.

| | | |
|---|---|---|
| veg. cell, | 37-48 μ diam., | 1½-3 diam. long. |
| oog., | 56-63 μ " | 56-67 μ long. |
| oos., | 48-59 μ " | 48-59 μ " |
| anth. cell, | 37-44 μ " | 5-9 μ " |

California.

Noticeable in this species is the fact that the oogonia project but little beyond the vegetative cells; a few other species are similar, but they are all dioecious.

15. OE. CAPILLIFORME Kützing, 1849, p. 367; Wolle, 1887, p. 88, Pl. LXXV, figs. 11-13; Hirn, 1900, p. 107, Pl. VIII, fig. 49; Roumeguère, Alg. Exsicc., No. 685, as *Oe. capillare.* Dioecious; oogonia single, slightly swollen, oboviform or sub-oboviform, pore superior; oospore ellipsoid-globose or cylindrical-globose and appearing quadrangular, sometimes with a slight constriction at the middle, more rarely globose or sub-globose, not filling the oogonium, membrane smooth; male plant slightly more slender than the female; antheridia 2-5-, rarely 10-celled, often alternating with the vegetative cells; spermatozoids binate, division horizontal; basal cell elongate, terminal cell obtuse or apiculate.

| | | |
|---|---|---|
| veg. cell, female, | 28-38 μ diam., | 1½-3 diam. long. |
| veg. cell, male, | 25-30 μ " | 1½-3 " " |
| oog., | 42-50 μ " | 51-62 μ long. |
| oos., | 37-45 μ " | 40-50 μ " |
| anth. cell, | 20-25 μ " | 8-10 μ " |

Reported by Wolle, but questioned by Hirn as to being of the type. From St. Louis, Mo., is recorded a forma *valida*, one-seventh to one-tenth larger.

Var. AUSTRALE Wittrock in Wittr. and Nordst., Alg. Exsicc., No. 704; Hirn, 1900, p. 109, Pl. IX, fig. 52; P. B.-A., No. 1189; *Oe. princeps* Wolle, 1887, p. 93, Pl. LXXVIII, fig. 3;

*Oe. stagnale* Wolle, 1887, p. 88, Pl. LXXXIII, figs. 3-6. Oogonia slightly less swollen and usually a little shorter, oboviform-globose or sub-globose; oospore globose or subglobose; dimensions between the type and forma *valida*. N. Y., Mexico, So. Dakota, Minn., Montana, Neb., Cal., Vancouver.
*Africa, So. America.*

Forma DIVERSUM Hirn, 1900, p. 110, Pl. IX, fig. 54; *Oe. stagnale* Tilden, Amer. Algae, Nos. 122, 545. A robust form, with oospores varying from depressed-globose to cylindric-globose; filaments a third to a fourth larger than in the type. Colorado, Montana, Minn.

Forma DEBARYANUM (Chmiel.) Hirn, 1900, p. 108, Pl. VIII, fig. 50. Oospore usually globose or subglobose, rarely cylindrical-globose, 38-50 $\mu$ diam., 40-53 $\mu$ long; other dimensions slightly smaller than in the type. Greenland. *Russia.*

A variable species, a number of other forms occurring in other countries; we have no species for which it is liable to be mistaken, if the organs of both sexes are well developed.

16. OE. CAPILLARE (L.) Kützing, 1843, p. 255, Pl. XII, figs. 1-10; Wolle, 1887, p. 87, Pl. LXXXIII, figs. 7 and 8; Hirn, 1900, p. 112, Pl. XI, fig. 58. Dioecious; oogonia single, little or not at all swollen, cylindrical or subcylindrical, pore superior; oospore not filling the oogonium, globose or somewhat cylindric-globose, sometimes slightly constricted at the middle, rarely depressed-quadrangular-globose, membrane smooth; male plant about the same size as the female or slightly less; antheridia 1-4-celled, usually alternating with vegetative cells; spermatozoids binate, division horizontal; basal cell elongate, terminal cell obtuse or short-apiculate.

| | | |
|---|---|---|
| veg. cell, female, | 38-55 $\mu$ diam., | 1-2 diam. long. |
| veg. cell, male, | 35-50 $\mu$ " | 1-2 " " |
| oog., | 40-60 $\mu$ " | 45-75 $\mu$ long. |
| oos., | 30-52 $\mu$ " | 36-65 $\mu$ " |
| anth. cell, | 30-48 $\mu$ " | 5-10 $\mu$ " |

Only known here by the general report by Wolle, without locality. *Europe.*

MACRANDRIA, PORIFERA, ELLIPSOSPORA.

17. OE. UPSALIENSE Wittrock, 1870, p. 125; Hirn, 1900, p. 115, Pl. XII, fig. 60; Wittr. and Nordst., Alg. Exsicc., No. 18. Monoecious; oogonia single, oboviform or suboblong-ellipsoid, pore superior; oospore same form as the oogonium, filling the latter, membrane smooth; antheridia 1-2-(rarely 3-) celled, subhypogynous; antheridia, oogonia and vegetative cells

often alternating; spermatozoids binate, division vertical; vegetative cells varying much in diameter in the same filaments; suffultory cells often larger and shorter than the others; basal cell elongate, terminal cell obtuse.

| | | |
|---|---|---|
| veg. cell, | 13-20 μ diam., | 4-8 diam. long. |
| oog., | 45-50 μ " | 66-100 μ long. |
| oos., | 42-47 μ " | 60-75 μ " |
| anth. cell, | 15-18 μ " | 7-10 μ " |

Greenland, N. H., Michigan. *Europe.*

A special character of this species is the variation in size of the cells in the same filament. The cells under the oogonia are the stoutest and shortest, those directly over the oogonia the longest and most slender. The antheridial cells are very seldom over 2 in a series.

18. OE. RICHTERIANUM Lemmerman, 1895, p. 26, figs. 1-3; Hirn, 1900, p. 117, Pl. XII, fig. 63; P. B.-A., No. 1429. Monoecious; oogonia single or 2, oboviform or subellipsoid, pore superior; oospore suboboviform or subellipsoid, rarely globose-ellipsoid, quite or nearly filling the oogonium, membrane smooth; antheridia 1-6-celled, subhypogynous, subepigynous or scattered; spermatozoids binate, division horizontal; basal cell usually elongate.

| | | |
|---|---|---|
| veg. cell, | 12-21 μ diam., | 3-6½ diam. long. |
| oog., | 36-48 μ " | 48-74 μ long. |
| oos., | 35-43 μ " | 43-59 μ " |
| anth. cell, | 12-15 μ " | 6-9 μ " |

Mass. *Europe.*

19. OE. RIVULARE (LeCl.) A. Braun, 1855a, p. 23, Pl. I, figs. 1-10; Wolle, 1887, p. 92, Pl. LXXXIII, figs. 1 and 2; Hirn, 1900, p. 119, Pl. XII, fig. 66; Phyk. Univ., No. 70. Dioecious; oogonia single or 2-7-seriate, oboviform, pore superior; oospore oboviform, ellipsoid or subglobose, not nearly filling the oogonium, membrane smooth; male plant somewhat more slender than the female; antheridia to 13-celled; spermatozoids binate, division horizontal; basal cell elongate.

| | | |
|---|---|---|
| veg. cell, female, | 35-45 μ diam., | 3-8 diam. long. |
| veg. cell, male, | 30-36 μ " | 4-8 " " |
| oog., | 70-85 μ " | 130-160 μ long. |
| oos., | 55-70 μ " | 65-100 μ " |
| anth. cell, | 21-28 μ " | 14-26 μ " |

Iowa, Florida. *Northern Europe.*

A large species, easily recognizable by the size, the oogonia many in a series, and the oospore much smaller than the oogonium; the antheridia are usually many in a series. Wolle's reference appears to be the only authority for its occurrence in America.

20. OE. PALUDOSUM (Hass.) Wittrock, 1870, p. 124; Wolle, 1887, p. 74, Pl. LXXV, fig. 1; Hirn, 1900, p. 120, Pl. XIII, fig. 69. Monoecious; oogonia single, ellipsoid, pore superior; oospore ellipsoid, filling the oogonium, membrane triple, outer and middle layers with longitudinal lines, 27-35 in number, continuous, rarely anastomosing; antheridia 1-8-celled, scattered, often in the upper part of the filament; spermatozoids binate, division vertical.

| | | |
|---|---|---|
| veg. cell, | 15-20 μ diam., | 3-7 diam. long. |
| oog., | 39-48 μ " | 66-84 μ long |
| oos., | 36-45 μ " | 54-63 μ " |
| anth. cell, | 14-16 μ " | 6-13 μ " |

Type reported by Wolle from Pa., but questioned by Hirn.

*Northern Europe.*

Var. AMERICANUM Nordstedt in Hirn, 1900, p. 121, Pl. XIII, fig. 72. Oogonia larger, ellipsoid; oospore of same shape, filling the oogonium.

| | | |
|---|---|---|
| veg. cell, | 14-23 μ diam., | 3-7 diam. long. |
| oog., | 54-63 μ " | 75-90 μ long. |
| oos., | 49-57 μ " | 69-75 μ " |
| anth. cell, | 12-18 μ " | 7-12 μ " |

So. Carolina.

The peculiar sculpture of the spore is sufficient to distinguish this and the following species from all others. The outer surface of the external membrane is smooth, but its inner surface and the outer surface of the median membrane are marked with longitudinal lines, arranged like the meridians of a sphere. The two species are distinct in the arrangement of the organs of fructification, *Oe. paludosum* being monoecious, *Oe. Boscii* dioecious.

21. OE. BOSCII (LeCl.) Wittrock, 1870, p. 136; Wolle, 1887, p. 91, Pl. LXXXII, figs. 11-13; Hirn, 1900, p. 122, Pl. XIII, fig. 73; Wittr., Nordst. and Lagerh., Alg. Exsicc., No. 1213. Dioecious; oogonia single (very rarely double) oblong-ellipsoid, pore superior; oospore ellipsoid, not nearly filling the oogonium; marked as in *Oe. paludosum;* male plant somewhat more slender than the female.

| | | |
|---|---|---|
| veg. cell, female, | 14-23 $\mu$ diam., | 3-6 diam. long. |
| veg. cell, male, | 13-18 $\mu$ " | 4-6 " " |
| oog., | 39-51 $\mu$ " | 75-110 $\mu$ long. |
| oos., | 36-43 $\mu$ " | 56-70 $\mu$ " |
| anth. cell, | 13-14 $\mu$ " | 6-16 $\mu$ " |

Greenland, Mass., Conn., Cal. *Europe, So. America.*

Forma DISPAR Hirn, 1900, p. 124, Pl. XIV, fig. 76; P. B.-A., No. 1226. Oospore smaller, ellipsoid-globose or sub-globose; oogonia shorter, sometimes suboviform.

| | | |
|---|---|---|
| veg. cell, | 14-21 $\mu$ diam., | 4-7 diam. long. |
| oog., | 38-45 $\mu$ " | 70-92 $\mu$ long. |
| oos., | 34-43 $\mu$ " | 44-55 $\mu$ " |

Mass., Pa., Cal.

Var. OCCIDENTALE Hirn, 1900, p. 125, Pl. XIV, fig. 77. More slender in all parts, vegetative cells longer; male plant same diameter as the female.

| | | |
|---|---|---|
| veg. cell, female, | 8-15 $\mu$ diam., | 6-11 diam. long. |
| veg. cell, male, | 8-15 $\mu$ " | 6-11 " " |
| oog., | 33-38 $\mu$ " | 75-100 $\mu$ long. |
| oos., | 32-37 $\mu$ " | 45-50 $\mu$ " |
| anth. cell, | 12-13 $\mu$ " | 10-16 $\mu$ " |

Kittery, Maine.

22. OE. MARGARITIFERUM Nordstedt and Hirn in Hirn, 1900, p. 128, Pl. XV, fig. 83. Dioecious; oogonia single, suboblong or suboviform-ellipsoid or subellipsoid, pore superior; oospore ellipsoid or globose-ellipsoid, not nearly filling the oogonium, or rarely nearly filling it; membrane triple, with longitudinal lines on the inner surface of the outer membrane and the outer surface of the median membrane; lines 30-35, sometimes anastomosing, not continuous, but made up of somewhat elongate dots; male plant somewhat more slender than the female; antheridia to 10-celled; spermatozoids binate, division vertical.

| | | |
|---|---|---|
| veg. cell, female, | 23-28 $\mu$ diam., | 3½-7 diam. long. |
| veg. cell, male, | 17-23 $\mu$ " | 4½-7 " " |
| oog., | 50-63 $\mu$ " | 82-100 $\mu$ long. |
| oos., | 48-61 $\mu$ " | 55-75 $\mu$ " |
| anth. cell, | 18-20 $\mu$ " | 7-13 $\mu$ " |

*So. America.*

Hirn considers as probably belonging to this species the plant figured by Wood, 1872, Pl. XVIII, fig. 4, but not named, and on this probability it is here included. It varies considerably in the size and shape of the oogonium and oospore, but on careful examination should be easily distinguished by the dotted, not continuous "meridians" on the spore.

23. OE. CRENULATO-COSTATUM Wittrock, 1878, p. 139; Hirn, 1900, p. 129, Pl. XV, fig. 84; P. B.-A., Nos. 810, 1426. Dioecious; oogonia single or 2-3, rarely 4-5, oboviform or subellipsoid, rarely oblong-ellipsoid, pore superior; oospore same form as the oogonium, filling or nearly filling the latter, membrane triple, external membrane smooth, median membrane with 14-20 longitudinal, crenulate, sometimes anastomosing lines; male plant somewhat more slender than the female; antheridia 2-6-celled, often alternating with vegetative cells; spermatozoids binate, division horizontal; terminal cell, which not infrequently is an oogonium, obtuse or short-apiculate.

| | | |
|---|---|---|
| veg. cell, female, | 10-18 $\mu$ diam., | 2½-7 diam. long. |
| veg. cell, male, | 9-13 $\mu$ " | 3½-6 " " |
| oog., | 30-36 $\mu$ " | 40-65 $\mu$ long. |
| oos., | 28-34 $\mu$ " | 37-55 $\mu$ " |
| anth. cell, | 9-12 $\mu$ " | 9-14 $\mu$ " |

Mass., Conn., N. Y., Pa.

Forma CYLINDRICUM Hirn, 1900, p. 129, Pl. XV, fig. 85; P. B.-A., No. 118, as *Oe. Boscii.* Ooogonia and oospores of variable form, generally cylindric-oblong, rarely ellipsoid or obovate-ellipsoid; longitudinal lines slightly crenate or almost entire; oogonia single or 2-4; vegetative cells slender.

| | | |
|---|---|---|
| veg. cell, | 11-16 $\mu$ diam., | 4-10 diam. long. |
| oog., | 30-36 $\mu$ " | 42-81 $\mu$ long. |
| oos., | 27-34 $\mu$ " | 40-65 $\mu$ " |

Mass., Conn., Mo.

Var. AUREUM Tilden, Amer. Algae, No. 123; 1898, p. 90, Pl. VIII, fig. 1-3; Hirn, 1900, p. 130, Pl. XV, fig. 87. Slender, oogonia shorter than in the type, single or 2-3; oospore obovoid to globose-ellipsoid, not quite filling the oogonium; lines of the oospore only scantily toothed, connected by distinct cross-lines.

| | | |
|---|---|---|
| veg. cell, | 10-13 $\mu$ diam., | 3½-9 diam. long. |
| oog., | 30-35 $\mu$ " | 38-50 $\mu$ long. |
| oos., | 29-33 $\mu$ " | 35-43 $\mu$ " |

In warm water, Yellowstone National Park.

The peculiar character of the "meridians" identifies this species in its various forms, much as the latter differ in other particulars. Hirn thinks it probable that under this name should be included *Oe. apiculatum* Wolle, 1877a, p. 188.

24. OE. TAPHROSPORUM Nordstedt and Hirn in Hirn, 1900,

p. 133, Pl. XVI, fig. 91; P. B.-A., No. 813. Dioecious; oogonia 2-6 or single, oboviform or oboviform-ellipsoid, pore superior; oospore globose or ellipsoid-globose, not filling or nearly filling the oogonium, membrane double, outer membrane pitted, inner smooth; male plants about the same size as the female; antheridium 2-?-celled; terminal cell, which sometimes is an oogonium, obtuse.

| | | |
|---|---|---|
| veg. cell, female, | 25-38 μ diam., | 4-10 diam. long. |
| veg. cell, male, | 26-33 μ " | 4-9 " " |
| oog., | 70-83 μ " | 81-113 μ long. |
| oos., | 58-65 μ " | 62-70 μ " |
| anth. cell, | 24-32 μ " | 8-12 μ " |

Mass. *So. America.*

25. OE. PUNCTATUM Wittrock, 1878, p. 142; Hirn, 1900, p. 132, Pl. XV, fig. 89. Dioecious; oogonia 2-4-seriate or single, oboviform, rarely globose-oboviform, pore superior; oospore oboviform, almost filling the oogonium, rarely subglobose, and then not filling the oogonium, membrane double, outer membrane densely pitted, inner membrane smooth; male plants about the size of the female; antheridia 1-5-celled, often alternating with the vegetative cells; spermatozoids binate, division horizontal; basal cell elongate; terminal cell, which is frequently an oogonium, obtuse.

| | | |
|---|---|---|
| veg. cell, female, | 15-22 μ diam., | 3-6 diam. long. |
| veg. cell, male, | 15-22 μ " | 3-6 " " |
| oog., | 38-45 μ " | 52-65 μ long. |
| oos., | 37-43 μ " | 43-55 μ " |
| anth. cell, | 15-17 μ " | 6-10 μ " |

Vera Cruz, Mexico.

A species closely resembling this, *Oe. scrobiculatum* Wittr., has been described from Equador; the dimensions are somewhat larger, the vegetative cells in the female plant ranging from 16-30 μ; the oogonia are usually solitary.

26. OE. MARTINICENSE Hirn, 1900, p. 134, Pl. XVI, fig. 92; *Oe. crassum* Wolle, 1887, p. 74, Pl. LXXVI, figs. 2 and 3. Monoecious; oogonia single, oboviform or suboboviform, pore superior; oospore oboviform or oboviform-ellipsoid, almost filling the oogonium, membrane smooth, usually rather thick; antheridia 1-5-celled, hypogynous; spermatozoids binate, division vertical.

| | | |
|---|---|---|
| veg. cell, | 33-37 μ diam., | 3½-6½ diam. long. |
| oog., | 68-74 μ " | 96-124 μ long. |
| oos., | 66-72 μ " | 81-96 μ " |
| anth. cell, | 33-35 μ " | 5-7 μ " |

Iowa, Kansas, Island of Martinique.

Resembles *Oe. Landsboroughii*, but the latter is dioecious.

27. OE. LANDSBOROUGHII (Hass.) Wittrock, 1874, p. 35; Wolle, 1887, p. 91, Pl. LXXXI, figs. 8-11; Hirn, 1900, p. 135, Pl. XVI and XVII, fig. 94; P. B.-A., No. 663. Dioecious; oogonia single, rarely 2, oboviform or suboboviform, pore superior; oospore oboviform to ellipsioid, filling or not quite filling the oogonium, membrane smooth; male plant generally a little more slender than the female; antheridia to 25-celled; spermatozoids binate, division vertical; basal cell elongate, apical cell obtuse.

| | | |
|---|---|---|
| veg. cell, female, | 31-40 $\mu$ diam., | 3-6 diam. long. |
| veg. cell, male, | 30-37 $\mu$ " | 4-6 " " |
| oog., | 63-75 $\mu$ " | 85-110 $\mu$ long. |
| oos., | 59-70 $\mu$ " | 73-102 $\mu$ " |
| anth. cell, | 27-35 $\mu$ " | 9-20 $\mu$ " |

Mass., Conn., N. Y., Mexico. *Europe, So. America.*

A widely distributed species, and varying somewhat, but not as much as some other species; a form has been found in Mexico with veg. cells 37-51 $\mu$ diam., otherwise like the type.*

28. OE. OBOVIFORME Wittrock, 1878, p. 140; Hirn, 1900, p. 141, Pl. XX, fig. 103. Dioecious; oogonia single, oboviform, pore superior; oospore oboviform, about filling the oogonium, rarely ellipsoid-oboviform, and then not quite filling the oogonium, membrane smooth; male plant about the same size as the female; antheridia to 19-celled; spermatozoids binate, division vertical; basal cell elongate.

| | | |
|---|---|---|
| veg. cell, female, | 21-33 $\mu$ diam., | 3½-9 diam. long. |
| veg. cell, male, | 21-31 $\mu$ " | 3½-9 " " |
| oog., | 55-65 $\mu$ " | 80-107 $\mu$ long. |
| oos., | 54-61 $\mu$ " | 70-85 $\mu$ " |
| anth. cell, | 21-28 $\mu$ " | 5-13 $\mu$ " |

Vera Cruz, Mexico. *So. America.*

Quite close to *Oe. grande*, but distinguished by the oboviform oogonia.

29. OE. PACHYANDRIUM Wittrock in Wittr. and Nordst., Alg. Exsicc., No. 5; Wolle, 1887, p. 89, Pl. LXXV, figs. 9 and 10; Hirn, 1900, p. 142, Pl. XX, fig. 104. Dioecious; oogonia single or rarely 2, very rarely 3, suboboviform or

*Wolle, 1887, p. 92, Pl. LXXVI, figs. 7 and 8, describes a new var. *major* of *Oe. rivulare* (LeCl.) A. Br.; Hirn, 1887, p. 141, thinks that this may belong under *Oe. crassum*, forma *amplum* (Magn. & Wille) Hirn; resembling *Oe. Landsboroughii*, but of larger dimensions; the dimensions given by Wolle are, however, larger than anything recorded for any form of *Oe. crassum*.

oboviform-ellipsoid, pore superior; oospore ellipsoid, not filling the oogonium, membrane smooth; male plant generally somewhat stouter than the female; antheridia 1-4-celled; spermatozoids binate, division vertical.

| | | |
|---|---|---|
| veg. cell, female, | 30-36 μ diam., | 3-6½ diam. long. |
| veg. cell, male, | 32-45 μ " | 2-3½ " " |
| oog., | 53-47 μ " | 84-108 μ long. |
| oos., | 51-57 μ " | 69-85 μ " |
| anth. cell, | 30-43 μ " | 11-20 μ " |

Pa. and N. J., according to Wolle, but questioned by Hirn. The species so much resembles forms of *Oe. grande* that it is quite possible that Wolle's plants were really the latter, which occurs at a number of American stations.

30. OE. GRANDE Kützing, 1845, p. 200; Wolle, 1887, p. 95, Pl. LXXVI, fig 1; Hirn, 1900, p. 143, Pl. XXI, fig. 105; P. B.-A., No. 811. Dioecious; oogonia single, rarely 2-5, slightly swollen, suboboviform, pore superior; oospore same form as the oogonium, not quite filling it, membrane smooth; male plant slightly more slender than the female; antheridia 1-8-celled; spermatozoids binate, division vertical; basal cell elongate.

| | | |
|---|---|---|
| veg. cell, female, | 28-37 μ diam., | 2½-5 diam. long. |
| veg. cell, male, | 28-33 μ " | 2½-5 " " |
| oog., | 49-60 μ " | 86-100 μ long. |
| oos., | 47-58 μ " | 64-93 μ " |
| anth. cell, | 25-33 μ " | 11-18 μ " |

Ontario, Me., Mass., Conn., Pa., Cal. *Europe, Australia.*

A species of varying forms, some of which have received names in Hirn's monograph, some being only mentioned, without name. Among the latter is the form from Massachusetts, distributed as P. B.-A., No. 519, with veg. cells 4-11 diam. long, oogonia up to 126 μ long, oospores to 104 μ, the diameter about as in the type; while among the named varieties is

Var. ANGUSTUM Hirn, 1900, p. 146, Pl. XXI, fig. 110; P. B.-A., No. 410. Slender, veg. cells and oogonia elongate, antheridia to 36 cells, oogonia sometimes 4 in succession.

| | | |
|---|---|---|
| veg. cell, female, | 19-30 μ diam., | 3½-11 diam. long. |
| veg. cell, male, | 19-25 μ " | 4-9 " " |
| oog., | 42-52 μ " | 62-110 μ long. |
| oos., | 40-50 μ " | 60-89 μ " |
| anth. cell, | 18-22 μ " | 7-15 μ " |

Mass. *So. America.*

Var. AEQUATORIALE forma HORTENSE Wittrock in Wittr. and Nordst., Alg. Exsicc., No. 1017; Hirn, 1900, p. 145, Pl. XXI, fig. 109. Smaller than the type in all parts, oospores less completely filling the oogonium, sometimes globose-ellipsoid, and then not nearly filling the oogonium.

| | | |
|---|---|---|
| veg. cell, female, | 24-33 μ diam., | 2-4½ diam. long. |
| oog., | 42-51 μ " | 63-88 μ long. |
| oos., | 38-49 μ " | 48-72 μ " |

These measures are for forma *hortense;* in the variety the vegetative cells and oogonia are proportionately longer. Greenland. *Ecuador.*

31. OE. MEXICANUM Wittrock, 1878, p. 138; Hirn, 1900, p. 147, Pl. XXII, fig. 111; Tilden, Amer. Algae, No. 257. Dioecious; oogonia single, slightly swollen, cylindric-obovi-form, pore superior; oospore of the same form as the oogonium, filling or nearly filling it, membrane smooth; male plant a little more slender than the female; antheridia to 8-celled; spermatozoids binate, division vertical.

| | | |
|---|---|---|
| veg. cell, female, | 34-41 μ diam., | 1¾-3½ diam. long. |
| veg. cell, male, | 30-38 μ " | 2-3 " " |
| oog., | 53-63 μ " | 76-110 μ long. |
| oos., | 51-60 μ " | 63-80 μ " |
| anth. cell, | 28-35 μ " | 7-17 μ " |

Mass., So. Dakota, Mexico.

Nearly related to *Oe. grande*, but with vegetative cells averaging larger and considerably shorter, oogonia more nearly cylindrical, and more completely filled by the oospore.

## MACRANDRIA, OPERCULATA, GLOBOSPORA.

32. OE. PUNCTATO-STRIATUM De Bary, 1854, p. 47, Pl. II, figs. 15 and 16; Wolle, 1887, p. 91, Pl. LXXXV, figs. 3-5; Hirn, 1900, p. 152, Pl. XXIII, fig. 123; Rabenhorst, Algen, Nos. 214, 2276. Diocecious; oogonia single, depressed-globose, operculate, division median; oospore depressed-globose, not quite filling the oogonium, membrane smooth; male plant slightly more slender than the female; antheridia to 10-celled, cells slightly swollen; spermatozoid single; membrane of the vegetative cells and oogonia marked with spirally placed dot-like pores; basal cell depressed-globose or subhemispherical, not elongate, membrane vertically plicate.

| | | |
|---|---|---|
| veg. cell, female, | 18-22 μ diam., | 2-6 diam. long. |
| veg. cell, male, | 16-19 μ " | 2-6 " " |
| oog., | 48-55 μ " | 38-48 μ long. |
| oos., | 40-51 μ " | 35-43 μ " |
| anth. cell, | 16-19 μ " | 6-12 μ " |
| basal cell, | 28-31 μ " | 21-25 μ " |

Greenland, Florida. *Europe, So. America.*

Quite distinct from other American species, by the spiral markings of the cell walls, as well as by other characters. The Florida locality, Wolle's determination, is perhaps doubtful.

33. OE. HOWARDII G. S. West, 1904, p. 281, Pl. CCCCLXIV, figs. 1-5. Dioecious; oogonia solitary, globose or subglobose, operculate, division median; oospore globose or sub-depressed-globose, filling the oogonium; antheridia pluricellular; spermatozoid single; vegetative cells slightly but distinctly capitellate; basal cell of filament subhemispherical or subspherical, not elongate.

| | | |
|---|---|---|
| veg. cell, female, | 9.5-11 μ diam. | 2-4 diam long. |
| veg. cell, male, | 7.5-9 μ " | 2-4 " " |
| oog., | 29-33 μ " | 29-33 μ long. |
| oos., | 25-29 μ " | 25-29 μ " |
| anth. cell, | 7.5-9 μ " | 8-14 μ " |
| basal cell, | 14-16 μ " | 10-11 μ " |

Barbados.

With basal cell similar to *Oe. punctato-striatum*, but smaller in all dimensions, and without the spiral markings of the latter species.

34. OE. PITHOPHORAE Wittrock, 1878, p. 141; Hirn, 1900, p. 157, Pl. XXIV, fig. 134. Monoecious; oogonia single, pyriform-globose, operculate, division superior; oospore globose, almost filling the oogonium, membrane smooth, often thickish; antheridia 1 (or more?)-celled, subepigynous; basal cell elongate.

| | | |
|---|---|---|
| veg. cell, | 9-11 μ diam., | 2½-4½ diam. long. |
| oog., | 26-30 μ " | 27-35 μ long. |
| oos., | 25-29 μ " | 24-29 μ " |
| anth. cell, | 8-10 μ " | 7-9 μ " |

St. Thomas, W. I., epiphytic on *Pithophora Cleveana*.

35. OE. CRISPUM (Hass.) Wittrock, 1874, p. 10; Wolle, 1887, p. 72, Pl. LXXIV, figs. 11-15; Hirn, 1900, p. 159, Pl. XXV, fig. 138; Wittr. and Nordst., Alg. Exsicc., Nos. 209, 508; Tilden, American Algae, No. 543. Monoecious; oogonia single, very rarely 2, oboviform-globose, operculate, division

superior; oospore globose or subglobose, almost filling the oogonium, membrane smooth; antheridium 1-5-celled, subepigynous or hypogynous; spermatozoids binate, division horizontal; basal cell elongate, terminal cell obtuse.

| | | |
|---|---|---|
| veg. cell, | 12-16 μ diam., | 3-4½ diam. long. |
| oog., | 37-45 μ " | 41-53 μ long. |
| oos., | 35-43 μ " | 37-43 μ " |
| anth. cell, | 8-14 μ " | 7-12 μ " |

Greenland, Pa., Vancouver, Minn., Alaska, Cal.
*Europe, Asia, Africa, Australia, So. America.*

Perhaps the commonest and most widely distributed species of the genus, and including many varieties and forms, two of which occur within our limits.

Var. GRACILESCENS Wittrock in Wittr. and Nordst., Alg. Exsicc., No. 509; Hirn, 1900, p. 162, Pl. XXV, fig. 143; P. B.-A., No. 518. Slender, oogonia and oospores varying in form, oogonia oboviform-globose to oboviform-pyriform or subellipsoid, generally single, rarely 2 or 3; oospores globose to ellipsoid.

| | | |
|---|---|---|
| veg. cell, | 10-14 μ diam., | 3-5 diam. long. |
| oog., | 33-39 μ " | 33-51 μ long. |
| oos., | 32-37 μ " | 33-42 μ " |
| anth. cell, | 9-10 μ " | 7-9 μ " |

Mass., Minn., (Pa.?), Mo. *So. America.*

The Pa. locality is surmised from Wolle's figure, which may represent this variety, though given as *Oe. vernale* (Hass.) Wittr.

Var. URUGUAYENSE Magnus and Wille in Wille, 1884, p. 39, Pl. II, fig. 63; Hirn, 1900, p. 164, Pl. XXVI, fig. 145; Wittr. and Nordst., Alg. Exsicc., No. 311, as *Oe. crispum* f. *typicum*. Smaller, veg. cells shorter, oogonia single, subboviform-globose; oospore filling the oogonium; antheridia subepigynous, hypogynous or sometimes scattered.

| | | |
|---|---|---|
| veg. cell, | 10-14 μ diam., | 1¾-3½ diam. long. |
| oog., | 30-38 μ " | 33-43 μ long. |
| oos., | 27-35 μ " | 27-37 μ " |
| anth. cell, | 8-13 μ " | 6-12 μ " |

Pa. *So. America.*

36. OE. OBESUM (Wittr.) Hirn, 1900, p. 166, Pl. XXVI, fig. 148. Monoecious; oogonia single, oboviform-globose, operculate, division superior; oospore globose, not quite filling the oogonium, membrane smooth, often thickened; antheridia 1-2-

celled, subepigynous or more rarely subhypogynous; spermatozoids binate, division horizontal.

| | | |
|---|---|---|
| veg. cell, | 12-15 μ diam., . | 2½-5 diam. long. |
| oog., | 40-43 μ " | 38-44 μ long. |
| oos., | 33-35 μ " | 33-35 μ " |
| anth. cell, | 11-14 μ " | 10-15 μ " |

Mass. *Europe.*

Resembles *Oe. crispum*, but the oospores are smaller in proportion to the oogonia, and the oogonia are always solitary; from *Oe. autumnale* it is distinguished by the smaller but longer vegetative cells.

37. OE. AUTUMNALE Wittrock, 1874, p. 11; Wolle, 1887, p. 73, Pl. LXXXI, figs. 1-5; Hirn, 1900, p. 167, Pl. XXVI, fig. 151. Monoecious; oogonia single, oboviform-globose, operculate, division superior; oospore globose or subglobose, filling or nearly filling the oogonium, membrane smooth; antheridia 1-2-celled, subepigynous, hypogynous or scattered; spermatozoids binate, division horizontal; basal cell elongate, terminal cell shortly acute.

| | | |
|---|---|---|
| veg. cell, | 16-20 μ diam., | 1½-2½ diam. long. |
| oog., | 39-45 μ " | 45-51 μ long. |
| oos., | 37-42 μ " | 37-44 μ " |
| anth. cell, | 15-18 μ " | 9-10 μ " |

Pa. *Europe.*

Not far from *Oe. crispum*, but with stouter and shorter vegetative cells, and relatively less swollen oogonia. Its occurrence in America has no other proof than the reference in Wolle.

38. OE. PRINGSHEIMII Cramer, 1859, p. 17, Pl. I, figs. 1-4; Wolle, 1887, p. 90, Pl. LXXXII, figs. 4-6; Hirn, 1900, p. 170, Pl. XXVII, fig. 155; Rabenhorst, Algen, No. 790. Dioecious; oogonia 2-6-seriate or single, suboboviform-globose, operculate, division superior; oospore globose, almost filling the oogonium, membrane smooth, thickish; male plant slightly more slender than the female; antheridia to 10-celled, always alternating with vegetative cells; spermatozoids binate, division horizontal; basal cell elongate, terminal cell obtuse or short-apiculate.

| | | |
|---|---|---|
| veg. cell, female, | 14-20 μ diam., | 2-5 diam. long. |
| veg. cell, male, | 12-16 μ " | 2-4 " " |
| oog., | 35-43 μ " | 36-46 μ long. |
| oos., | 30-37 μ " | 30-37 μ " |
| anth. cell, | 11-15 μ " | 6-9 μ " |

N. Y., Pa., Florida. *Europe, Africa, Australia.*

A widely distributed species, but the occurrence with us of the typical form is recorded only by Wolle, who does not mention var. *Nordstedtii*, which certainly does occur here; possibly his plants belong rather to the variety.

Var. NORDSTEDTII Wittrock in Wittr. and Nordst., Alg. Exsicc., Nos. 8 and 205; Hirn, 1900, p. 171, Pl. XXVII, fig. 156. Smaller, oogonia single, rarely 2, oboviform-globose, oospore not quite filling the oogonium.

| | | |
|---|---|---|
| veg. cell, female, | 10-16 $\mu$ diam., | 2-4½ diam. long. |
| veg. cell, male, | 9-15 $\mu$ " | 2-4½ " " |
| oog., | 28-39 $\mu$ " | 36-45 $\mu$ long. |
| oos., | 26-34 $\mu$ " | 27-34 $\mu$ " |
| anth. cell, | 9-12 $\mu$ " | 8-9 $\mu$ " |

Greenland, Minnesota, Cal. *Europe, Asia.*

MACRANDRIA, OPERCULATA, ELLIPSOSPORA.

39. OE. AHLSTRANDII Wittrock in Wittr. and Nordst., Alg. Exsicc., No. 401; Hirn, 1900, p. 183, Pl. XXIX, fig. 179. Monoecious; oogonia ellipsoid, single, operculate, division superior; oospore ellipsoid, filling the oogonium, membrane smooth; antheridium 1-2-celled, hypogynous; spermatozoids binate, division horizontal; terminal cell obtuse.

| | | |
|---|---|---|
| veg. cell, | 10-18 $\mu$ diam., | 3-10 diam. long. |
| oog., | 34-42 $\mu$ " | 57-69 $\mu$ long. |
| oos., | 34-41 $\mu$ " | 53-62 $\mu$ " |
| anth. cell, | 13-17 $\mu$ " | 9-12 $\mu$ " |

N. Y. *Sweden.*

40. OE. GRACILLIMUM Wittrock and Lund in Wittrock, 1874, p. 15; Wolle, 1887, p. 74, Pl. LXXV, fig. 2; Hirn, 1900, p. 184, Pl. XXIX, fig. 180. Monoecious; oogonia single, oblong, operculate, division superior; oospore oblong-ellipsoid, not filling the oogonium, membrane smooth; antheridia subepigynous, hypogynous or subhypogynous, unicellular; spermatozoids binate, division horizontal.

| | | |
|---|---|---|
| veg. cell, | 3½-7 $\mu$ diam., | 4½-6 diam. long. |
| oog., | 14-19 $\mu$ " | 34-40 $\mu$ long. |
| oos., | 13-17 $\mu$ " | 24-32 $\mu$ " |
| anth. cell, | 3-5 $\mu$ " | 4-7 $\mu$ " |

Pa. *Europe.*

41. OE. NODULOSUM Wittrock, 1872, p. 22, Pl. I, figs. 8-10; Hirn, 1900, p. 187, Pl. XXIX, fig. 184. Monoecious; oogonia single or 2, oboviform-globose, more rarely oboviform-ellipsoid, operculate, division superior; oospore globose or subglobose, more rarely globose-ellipsoid, almost filling the oogonium, mem-

brane smooth, often thick; antheridia 1-3-celled, subepigynous or hypogynous; spermatozoids binate, division horizontal; vegetative cells with two undulate constrictions; basal cell elongate, not constricted; terminal cell obtuse or apiculate.

| | | |
|---|---|---|
| veg. cell, | 20-29 μ diam., | 1½-4½ diam. long. |
| oog., | 48-57 μ " | 56-73 μ long. |
| oos., | 46-53 μ " | 49-56 μ " |
| anth. cell, | 18-25 μ " | 7-9 μ " |

The type occurs in Europe, Asia, Australia, and So. America, but has not been reported from No. America; but we have

Var. COMMUNE Hirn, 1900, p. 187, Pl. XXX, fig. 185; P. B.-A., No. 74, as *Oe. nodulosum*. Oogonia and oospores larger, the former suboboviform-ellipsoid to ellipsoid, more rarely globose-ellipsoid.

| | | |
|---|---|---|
| veg. cell, | 22-29 μ diam., | 1½-4½ diam. long. |
| oog., | 64-74 μ " | 70-90 μ long. |
| oos., | 56-70 μ " | 67-80 μ " |
| anth. cell, | 18-26 μ " | 7-10 μ " |

Mass. *Finland.*

The specific name is due to the constrictions in the vegetative cells, each cell appearing to consist of three parts, separated by necks. No other American species has this character.

42. OE. NOBILE Wittrock, 1874, p. 14; Hirn, 1900, p. 189, Pl. XXX, fig. 188. Monoecious; oogonia single, very rarely 2, ellipsoid or suboboviform-ellipsoid, operculate, division superior; oospore ellipsoid-globose or globose, not filling the oogonium, membrane triple; outer membrane smooth, median membrane with 30-35 continuous longitudinal lines, rarely anastomosing, inner membrane smooth; antheridia 1-3-celled, hypogynous; spermatozoids binate, division horizontal.

| | | |
|---|---|---|
| veg. cell, | 16-20 μ diam., | 5-9 diam. long. |
| oog., | 57-65 μ " | 67-90 μ long. |
| oos., | 48-55 μ " | 67-79 μ " |
| anth. cell, | 18-19 μ " | 9-13 μ " |

The dimensions given are of the type occurring in Norway; the American form, occurring in Mass., has dimensions as follows: —

| | | |
|---|---|---|
| veg. cell, | 14-20 μ diam., | 6-11 diam. long. |
| oog., | 57-63 μ " | 81-95 μ long. |
| oos., | 55-60 μ " | 67-79 μ " |
| anth. cell, | 14-19 μ " | 13-17 μ " |

As the characters otherwise agree, the form does not seem to require a special name. This species has the spore membrane similar to that of *Oe. Boscii*, but is distinguished by the operculate oogonium, as well as by other characters.

NANNANDRIA, ANTHERIDIUM EXTERIUS, PORIFERA, GLOBOSPORA.

43. OE. BRAUNII Kützing, 1849, p. 366; Wolle, 1887, p. 79, Pl. LXXIX, figs. 6 and 7; Hirn, 1900, p. 194, Pl. XXXII, fig. 197; Wittr. and Nordst., Alg. Exsicc., No. 15. Dioecious, nannandrous, gynandrosporous; oogonia single, ellipsoid or subglobose, pore median; oospore globose, not quite filling the oogonium, membrane smooth; suffultory cell slightly or not swollen; androsporangia 1-2-celled; basal cell elongate, terminal cell obtuse; dwarf males near the oogonia, often on the suffultory cell, stipe sometimes 5-celled, antheridium external, unicellular, stipe slightly curved.

| | | |
|---|---|---|
| veg. cell, | 13-15 μ diam., | 2-4 diam. long. |
| suf. cell, | 16-20 μ " | 1¾-2¼ " " |
| oog., | 30-37 μ " | 33-43 μ long. |
| oos., | 27-33 μ " | 27-33 μ " |
| andr. cell, | 13-15 μ " | 11-12 μ " |
| nan. stipe, | 7-12 μ " | 20-28 μ " |
| anth. cell, | 5-8 μ " | 9-10 μ " |

N. J., Pa. *Europe, Africa.*

44. OE. FLAVESCENS (Hass.) Wittrock, 1870, p. 127, Pl. LIII, fig. 9; Wolle, 1887, p. 78, Pl. LXXVIII, figs. 1 and 2; Hirn, 1900, p. 196, Pl. XXXII, fig. 199. Dioecious, nannandrous, idio- or gynandrosporous; oogonia single, ellipsoid or subglobose (sometimes sub-hexagonal-globose), pore median; oospore globose, not quite filling the oogonium, membrane smooth; suffultory cell similar to other veg. cells; androsporangia 1-9-celled; dwarf males slightly curved, on the suffultory cell, antheridium external, 1- (or 2-) celled.

| | | |
|---|---|---|
| veg. cell, | 18-23 μ diam., | 4-6 diam. long. |
| oog., | 49-52 μ " | 51-60 μ long. |
| oos., | 45-49 μ " | 45-49 μ " |
| andr. cell, | 17-20 μ " | 8-18 μ " |
| nan. stipe, | 11-12 μ " | 36-45 μ " |
| anth. cell, | 9-10 μ " | 15-20 μ " |

Mass., Minn. *Sweden.*

Somewhat like the preceding species in character, but of larger dimensions; the oogonium is often of hexagonal form when young, later becoming globose.

45. OE. PUNGENS Hirn, 1900, p. 199, Pl. XXXII, fig. 203.

Dioecious, nannandrous, gynandrosporous; oogonia single, depressed-globose or subglobose, pore median or slightly higher; oospore subglobose, nearly filling the oogonium, epispore covered with subuliform spines; suffultory cell similar to other veg. cells; androsporangia hypogynous, 1- (or more-?) celled; dwarf males slightly curved, on the suffultory cells, antheridium external, 1-2-celled.

| | | |
|---|---|---|
| veg. cell, | 12-16 μ diam., | 4-6 diam. long. |
| oog., | 40-48 μ " | 40-50 μ long. |
| oos., | 37-44 μ " | 35-43 μ " |
| andr. cell, | 14-16 μ " | 10-15 μ " |
| nan. stipe, | 9-12 μ " | 20-30 μ " |
| anth. cell, | 6-7 μ " | 8-12 μ " |

So. Carolina.

This species was collected by Ravenel, but the specimen remained unnoticed until Hirn found it and published it in his Monograph in 1900. It is quite similar in character to *Oe. aster*, a Swedish plant, also of a single station, which has a similar spinous oospore, but is smaller in all its dimensions, with longer cells; *Oe. echinospermum* has similar spines on the oospore, but has stouter vegetative cells, so that the oogonia do not appear so swollen; they are moreover ellipsoid instead of depressed.

46. OE. ECHINOSPERMUM A. Braun in Kützing, 1849, p. 366; Wolle, 1887, p. 86, Pl. LXXXIV, fig. 7; Hirn, 1900, p. 199, Pl. XXXIII, fig. 204; Wittr. and Nordst., Alg. Exsicc., Nos. 12, 506. Dioecious, nannandrous, gynandro- or idioandrosporous; oogonia single, ellipsoid-globose or subglobose, pore median; oospore globose, almost filling the oogonium, epispore with subulate spines; suffultory cell not swollen; androsporangia 1-5-celled, dwarf males slightly curved, on the suffultory cell, antheridium external, 1-2-celled.

| | | |
|---|---|---|
| veg. cell, | 18-30 μ diam., | 2½-4½ diam. long. |
| oog., | 39-50 μ " | 41-57 μ long. |
| oos., | 38-47 μ " | 38-49 μ " |
| andr. cell, | 21-25 μ " | 9-15 μ " |
| nan. stipe, | 10-15 μ " | 26-35 μ " |
| anth. cell, | 6-12 μ " | 6-15 μ " |

Mass., N. Y., N. J., Pa. *Europe.*

Var. HORRIDUM Hirn, 1900, p. 201, Pl. XXXIII, fig. 205; *Oe. echinospermum* var.? Wolle, 1887, p. 86, Pl. LXXXV, figs. 6-9. Larger, spines of the oospore longer and denser; antheridium pluricellular.

Florida.

The distinctions between *Oe. echinospermum* and *Oe. pungens* were given under the latter species; the var. *horridum* has quite a different appearance from the type, and when better known may prove to be a distinct species.

47. OE. IRREGULARE Wittrock, 1870, p. 128; Wolle, 1887, p. 79, Pl. LXXVIII, figs. 4 and 5; Hirn, 1900, p. 202, Pl. XXXIII, fig. 207. Dioecious, nannandrous; oogonia single, globose or subdepressed-globose, pore superior; oospore globose, filling the oogonium, membrane smooth; suffultory cell not swollen; dwarf males straight, near or on the oogonium; antheridium exterior, 1-4-celled.

| | | |
|---|---|---|
| veg. cell, | 15-20 μ diam., | 2½-4 diam. long. |
| oog., | 37-45 μ " | 36-47 μ long. |
| oos., | 36-42 μ " | 34-41 μ " |
| nan. stipe, | 12-15 μ " | 20-24 μ " |
| anth. cell, | 10-12 μ " | 6-8 μ " |

Florida. *Northern Europe.*

This species is in habit much like the monoecious *Oe. fragile;* the globose oogonia often occur throughout a long vegetative filament, with only one or two vegetative cells between; the short dwarf males are usually at right angles to the filament.

48. OE. ARMIGERUM Hirn, 1900, p. 203, Pl. XXXIII, fig. 208. Dioecious, nannandrous; oogonia single, subglobose, pore superior; oospore globose, almost filling the oogonium; epispore with subulate spines; suffultory cell similar to other veg. cells; dwarf males curved, on the suffultory cell, stipe not seldom 2-4-celled; antheridium exterior 1- (or more-?) celled.

| | | |
|---|---|---|
| veg. cell, | 9-11 μ diam., | 4-10 diam. long. |
| oog., | 29-33 μ " | 32-35 μ long. |
| oos., | 26-29 μ " | 26-29 μ " |
| lower cell, nan. stipe, | 7-8 μ " | 20-24 μ " |
| upper cell, nan. stipe, | 4.5-6 μ " | 21-30 μ " |
| anth. cell, | 5-6 μ " | 7-8 μ " |

*So. America.*

This species and the following, *Oe. echinatum*, are notably smaller than our other species with spinous spores; *Oe. echinatum* is larger than *Oe. armigerum*, with more spherical oogonia and oospores; the spines are, moreover, rather conical than aculeate. The only reason for including *Oe. armigerum* here is that the figures given by Wolle for *Oe. echinatum* seem to Hirn to be more like *Oe. armigerum*, which was undescribed at the time Wolle's book was published, than like *Oe. echinatum*. They are much more complete than Wood's figures, but Wolle does not give the locality of the plant from which they were made.

49. OE. ECHINATUM (Wood) Wittrock, 1878a, p. 137; Hirn, 1900, p. 204; *Androgynia echinata* Wood, 1872, p. 198, Pl. XVIII, fig. 3. Dioecious, nannandrous; oogonia single, globose, usually depressed, pore superior; oospore same form as the oogonium, nearly filling it, epispore with narrowly conical spines; dwarf males nearly straight, near the oogonia.

| | | |
|---|---|---|
| veg. cell, | 8-12 μ diam., | 6-14 diam. long. |
| oog., | 35-36 μ " | |
| oos., | 25-26 μ " | 25-26 μ long. |

Pa.

A quite imperfectly known species; see notes under *Oe. armigerum*.

50. OE. STELLATUM Wittrock, 1870, p. 129; Wolle, 1887, p. 85, Pl. LXXXIV, figs. 1 and 2; Hirn, 1900, p. 205, Pl. XXXIV, fig. 210. Dioecious, nannandrous, gynandrosporous; oogonia single or 2-3, oboviform-globose, pore superior; oospore globose, about filling the oogonium, epispore with conical spines, arranged in 4-7 occasionally anastomosing spirals, suffultory cell hardly swollen; androsporangia 1-3-celled, generally subepigynous; basal cell elongate, terminal cell slender, hyaline, obtuse; dwarf males nearly straight, on the suffultory cells, antheridium exterior, 1-2-celled.

| | | |
|---|---|---|
| veg. cell, | 15-35 μ diam., | 3-6 diam. long. |
| oog., | 51-64 μ " | 56-70 μ long. |
| oos., | 50-58 μ " | 50-58 μ " |
| andr. cell, | 14-19 μ " | 13-20 μ " |
| nan. stipe, | 11-13 μ " | 45-52 μ " |
| anth. cell, | 6-9 μ " | 8-13 μ " |

Florida. *Europe, Africa, Australia, So. America.*

From the previously noted species with spinous spores this is distinguished by the spiral arrangement of the spines, which are also stouter and relatively shorter than in the species before mentioned. These characters it shares with *Oe. Donnellii*, which is, however, a larger plant in every way. The great variation in the diameter of the vegetative cells in the same filament is a noticeable character of this species.

51. OE. DONNELLII Wolle, 1880, p. 48; 1887, p. 85, Pl. LXXXIV, figs. 3-6; Hirn, 1900, p. 206, Pl. XXXIV, fig. 211. Dioecious, nannandrous, idioandrosporous; oogonia single, rarely double, slightly swollen, oboviform-globose, pore superior; oospore globose, not fully filling the oogonium; epispore with conical spines, arranged in 5-7 occasionally anastomosing spirals; suffultory cell not swollen; androsporangia 4-10-celled; dwarf males slightly curved, on the suffultory cell, rarely on the oogonium; antheridium exterior, 1-2-celled.

| | | |
|---|---|---|
| veg. cell, | 41-59 μ diam., | 1⅓-3 diam. long. |
| oog., | 63-78 μ " | 70-93 μ long. |
| oos., | 60-70 μ " | 60-70 μ " |
| andr. cell, | 40-45 μ " | 10-12 μ " |
| nan. stipe, | 16-21 μ " | 63-74 μ " |
| anth. cell, | 14-15 μ " | 8-22 μ " |

Florida.

Hirn's examination of authentic specimens enabled him to correct and complete the descriptions and figures of Wolle.

52. OE. HUNTII Wood, 1869, p. 333; 1872, p. 198, Pl. XVII, fig. 2; Wolle, 1887, p. 85, Pl. LXXXIV, fig. 9; Hirn, 1900, p. 208, Pl. XXXIV, fig. 213; P. B.-A., No. 1471. Dioecious, nannandrous; oogonia single, subglobose or suboboviform-globose, pore inferior; oospore globose, not filling the oogonium, epispore with four raised spiral lines; suffultory cell similar to other vegetative cells; basal cell elongate, terminal cell tapering, produced into a long hyaline seta; dwarf males nearly straight, on the suffultory cells; antheridium exterior, 1-(or 2-?) celled.

| | | |
|---|---|---|
| veg. cell, | 15-25 μ diam., | 2⅓-3⅓ diam. long. |
| oog., | 50-60 μ " | 52-60 μ long. |
| oos., | 38-42 μ " | 38-42 μ " |
| nan. stipe, | 11 μ " | 52 μ " |
| anth. cell, | 10 μ " | 30 μ " |

Mass., Pa.

Wood's record was long the only one for this species, which he found growing in his aquarium. Wolle merely condenses Wood's description, and Hirn copies it, and gives dimensions taken from Wood's figures. Its nearest relative seems to be *Oe. spirale* from Java, but in the latter the arrangement of the spirals is quite different. For occurrence in Mass., see Collins, 1908b, p. 57.

53. OE. SEXANGULARE Cleve in Wittrock, 1870, p. 131; Wolle, 1887, p. 82, Pl. LXXIX, figs. 8 and 9; Hirn, 1900, p.

211, Pl. XXXV, fig. 216; Wittr. and Nordst., Alg. Exsicc., No. 12. Dioecious, nannandrous, gynandrosporous; oogonia single, rarely double, sexangular-ellipsoidal, having the greatest width and the pore slightly above the middle; oospore same form as the oogonium, quite filling it, membrane smooth; suffultory cell not or slightly swollen; androsporangia 1-3-celled, dwarf males on suffultory cells, slightly curved; stipe sometimes 2-3-celled; antheridium exterior, unicellular.

| | | |
|---|---|---|
| veg. cell, | 9-16 μ diam., | 3-7 diam. long. |
| oog., | 29-33 μ " | 33-39 μ long. |
| oos., | 27-31 μ " | 31-36 μ " |
| andr. cell, | 13-14 μ " | 10-14 μ " |
| nan. stipe, | 7-9 μ " | 21-30 μ " |
| anth. cell, | 6-7 μ " | 9-12 μ " |

Pa. *Europe.*

Var. MAJUS Wille, 1880, p. 68; Hirn, 1900, p. 212, Pl. XXXV, fig. 217; P. B.-A., No. 522. Larger, oogonia most swollen at the middle, pore median.

| | | |
|---|---|---|
| veg. cell, | 15-23 μ diam., | 2-3 diam. long. |
| oog., | 36-42 μ " | 41-45 μ long. |
| oos., | 34-40 μ " | 39-43 μ " |
| andr. cell, | 14-18 μ " | 8-10 μ " |
| nan. stipe, | 7-9 μ " | 18-30 μ " |
| anth. cell, | 6-8 μ " | 6.5-10 μ " |

Mass. *Europe.*

The form of the oogonium easily distinguishes this from all other species, American or foreign.

54. OE. HYSTRIX Wittrock, 1870, p. 133; Wolle, 1887, p. 87, Pl. LXXXIV, fig. 8; Hirn, 1900, p. 213, Pl. XXXV, fig. 218. Dioecious, nannandrous, gynandrosporous (or possibly idioandrosporous); oogonia single, ellipsoid, pore median; oospore ellipsoid, nearly filling the oogonium, covered with subulate spines; suffultory cell little or not swollen; androsporangia 1-3-celled, terminal cell obtuse; dwarf males slightly curved, on the suffultory cell; antheridium exterior, unicellular.

| | | |
|---|---|---|
| veg. cell, | 17-28 μ diam., | $1\frac{2}{3}$-$4\frac{1}{2}$ diam. long. |
| oog., | 38-48 μ " | 45-65 μ long. |
| oos., | 37-46 μ " | 43-55 μ " |
| andr. cell, | 17-18 μ " | 13-18 μ " |
| nan. stipe, | 10-11 μ " | 22-25 μ " |
| anth. cell, | 6-8 μ " | 9-14 μ " |

Pa. *Europe.*

Distinguished from all other spinous species by the elongate spines and the very short dwarf males.

55. OE. CRASSIUSCULUM var. IDIOANDROSPORUM Wittr. and Nordst., Alg. Exsicc., Nos. 208, 310; Wolle, 1887, p. 80, Pl. LXXVII, figs. 14-19; Hirn, 1900, p. 215, Pl. XXXV, fig. 220; P. B.-A., Nos. 72, 716. Dioecious, nannandrous, idioandrosporous; oogonia single or 2, globose-oboviform to globose; oogonia ellipsoid-globose to angular-oboviform or angular-globose, nearly filling the oogonium; pore superior; membrane smooth, thick; suffultory cell similar to the other vegetative cells; androsporangia 2-5-celled; dwarf males nearly straight, on or near the suffultory cell; antheridium exterior, 1- (or more- ?) celled.

| | | |
|---|---|---|
| veg. cell, | 25-36 μ diam., | 2½-5½ diam. long. |
| oog., | 48-59 μ " | 57-90 μ long. |
| oos., | 42-57 μ " | 50-66 μ " |
| andr. cell, | 30-34 μ " | 12-21 μ " |
| nan. stipe, | 14-16 μ " | 60-70 μ " |
| anth. cell, | 8-10 μ " | 10-18 μ " |

Me., Mass., Conn., N. Y., N. J., Pa., Minn., So. Dakota.
*Northern Europe.*

The type, occurring in northern Europe, is gynandrosporous, and never has the angular oospores. The plants from Maine and Mass., distributed under No. 72, P. B.-A., have the oospores and oogonia broader and more globose, often 4 in a series; the androsporangia are more slender. From the three following species, resembling it in many particulars, *Oe. crassiusculum* in all its forms can be distinguished by the unswollen suffultory cell; the unusually thick membrane is also to be noted.

56. OE. BORISIANUM (Le Cl.) Wittrock, 1870, p. 132; Wolle, 1887, p. 81, Pl. LXXVIII, figs. 6-9; Hirn, 1900, p. 217, Pl. XXXVI, fig. 223; P. B.-A., No. 517. Dioecious, nannandrous, gynandrosporous or idioandrosporous; oogonia single, or rarely 2-3, oboviform or quadrangular-ellipsoid, pore superior; oospore ellipsoid or oboviform, sometimes quadrangular-ellipsoid, not quite filling the oogonium, membrane smooth; suffultory cell swollen; androsporangia 1-7-celled, in the upper part of the filament, often subepigynous; basal cell elongate; terminal cell, which may be an oogonium, short-apiculate or obtuse, or sometimes produced in a long, hyaline seta; dwarf males slightly curved, on suffultory cell; antheridium exterior, 1-2-celled.

| | | |
|---|---|---|
| veg. cell, | 15-23 μ diam., | 3-6 diam. long. |
| suf. cell, | 31-38 μ " | 1¾-2½ " " |
| oog., | 40-50 μ " | 55-90 μ long. |
| oos., | 35-46 μ " | 48-60 μ " |
| andr. cell, | 16-19 μ " | 15-23 μ " |
| nan. stipe, | 12-15 μ " | 35-47 μ " |
| anth. cell, | 7-10 μ " | 11-15 μ " |

Mass., Pa., Cal. *Europe, Australia, So. America.*

A common species, distinguished from *Oe. crassiusculum* by the much swollen cell below the oogonium; the cells are relatively slender just above the oogonium, and increase rapidly and uniformly to and including the oogonium; above this the cell is slender again; from the two following species, *Oe. Wolleanum* and *Oe. concatenatum*, it is distinguished by the oospore being smooth, not striate.

57. OE. WOLLEANUM Wittrock, 1878a, p. 137; Wolle, 1887, p. 82, Pl. LXXX, figs. 4 and 5; Hirn, 1900, p. 220, Pl. XXXVII, fig. 226; Wittr. and Nordst., Alg. Exsicc., No. 107. Dioecious, nannandrous, gynandrosporous or idioandrosporous; oogonia single or 2, more rarely 3-4, suboboviform or quadrangular-ellipsoid, pore superior, membrane with raised longitudinal lines on the inner surface; oospore same form as the oogonium, quite filling it, membrane double; external membrane with 25-35 longitudinal raised lines, rarely anastomosing; inner membrane smooth; suffultory cell swollen; androsporangia 1-3-celled, often subepigynous, or scattered in the upper part of the filament; basal cell elongate; terminal cell, which is sometimes an oogonium, short acute or acuminate; dwarf males on suffultory cell, stipe slightly curved; antheridium exterior, 1-3-celled.

| | | |
|---|---|---|
| veg. cell, | 21-30 μ diam., | 3-8 diam. long. |
| suf. cell, | 45-56 μ " | 1½-2 " " |
| oog., | 58-68 μ " | 69-89 μ long. |
| oos., | 56-66 μ " | 65-83 μ " |
| andr. cell, | 21-30 μ " | 18-25 μ " |
| nan. stipe, | 15-24 μ " | 54-60 μ " |
| anth. cell, | 9-14 μ " | 7-11 μ " |

Greenland, Mass., Conn., N. J., Pa., Minn., Fla.
*Europe, Asia, So. America.*

A cosmopolitan species, and generally quite uniform in its characters; it is distinguished from *Oe. Borisianum* and *Oe. concatenatum* by the lines on the oogonium and the oospore, the two fitting closely, the elevations on one into the furrows in the other; *Oe. Borisianum* has smooth spores; *Oe. concatenatum* has dotted lines on the median membrane of the oospore, but the outer membrane and the oogonium are smooth. One form and one variety are to be noticed.

Forma INSIGNE (Nordstedt) Hirn, 1900, p. 222, Pl. XXXVII, fig. 227. Stouter, lines on the oospore and oogonium 35-40, oogonia 1-10, androsporangia to 10-celled, antheridia 1-4-celled. The dimensions are one-fourth or one-fifth larger in all parts than in the typical form. N. J. *Sweden.*

Var. CONCINNUM Hirn, 1900, p. 222, Pl. XXXVII, fig. 228. Smaller; oospore not quite filling the oogonium; lines on the membrane of the oospore finely crenulate. The dimensions are about one-tenth smaller than in the type.

Minn.

58. OE. CONCATENATUM (Hass.) Wittrock, 1874, p. 25; Wolle, 1887, p. 81, Pl. LXXIX, figs. 1-3, and var. *setigerum* Wolle, 1887, p. 82, Pl. LXXIX, figs. 4 and 5; Hirn, 1900, p. 223, Pl. XXXVIII, fig. 230. Dioecious, nannandrous, gynandrosporous; oogonia single or 2-6, suboviform or quadrangular-ellipsoid, pore superior; oospore same form as the oogonium, nearly filling it, membrane apparently triple; outer membrane smooth, median membrane with pits, more or less distinctly arranged in 30-35 longitudinal series, inner membrane smooth; suffultory cell swollen; androsporangia 1-4-celled; basal cell elongate, terminal cell obtuse; dwarf males curved, on suffultory cell; antheridium exterior, 1-4-celled.

| | | |
|---|---|---|
| veg. cell, | 25-40 $\mu$ diam., | 3-10 diam. long. |
| suf. cell, | 50-62 $\mu$ " | $1\frac{3}{4}$-$2\frac{1}{2}$ " " |
| oog., | 63-83 $\mu$ " | 76-105 $\mu$ long. |
| oos., | 60-76 $\mu$ " | 67-95 $\mu$ " |
| andr. cell, | 25-28 $\mu$ " | 15-36 $\mu$ " |
| nan. stipe, | 17-25 $\mu$ " | 50-75 $\mu$ " |
| anth. cell, | 13-15 $\mu$ " | 12-25 $\mu$ " |

Mass., N. J., Pa., Alaska. *Europe.*

Various forms of this species are found in Europe, but only the type has been recorded in this country. The distinctions between this species and the three preceding have been already indicated.

59. OE. MULTISPORUM Wood, 1869, p. 141; Wolle, 1887, p. 78, Pl. LXXX, figs. 6 and 7; Hirn, 1900, p. 232, Pl. XXXIX, fig. 239. Dioecious, nannandrous; oogonia single or 2-3, suboviform or subglobose (pore superior?); oospore globose, nearly

filling the oogonium (membrane smooth?); (suffultory cell of same form as the other vegetative cells?); dwarf males slightly curved, near the oogonium; antheridium exterior, 1-(or more-?) celled.

| | | | |
|---|---|---|---|
| veg. cell, | 12-14 μ diam., | 1¼-1¾ diam. long. | |
| oog., | 31-35 μ " | 28-33 μ long. | |
| oos., | 27-29 μ " | 25-29 μ " | |
| nan. stipe, | 11 μ " | 26 μ " | |
| anth. cell, | 7-9 μ " | 9 μ " | |

Pa.

The description is incomplete, but is all that can be obtained from Wood's figures and text; no original specimens are known.

60. OE. MACRANDRIUM Wittrock, 1870, p. 130, Pl. I, figs. 3-5; Wolle, 1887, p. 80, Pl. LXXXII, figs. 1-3; Hirn, 1900, p. 233, Pl. XXXIX, fig. 240; Wittr. and Nordst., Alg. Exsicc., Nos. 108, 505, 1217. Dioecious, nannandrous; oogonia single or 2-3, rarely 4; globose-oboviform, operculate, division superior; oospore globose, more rarely oboviform-globose, not fully filling the oogonium, membrane smooth; suffultory cell of same form as the other vegetative cells; terminal cell obtuse or very shortly apiculate; dwarf males on or near the oogonium, stipe much curved, sometimes 2-3-celled; antheridia 1-7-celled.

| | | |
|---|---|---|
| veg. cell, | 15-20 μ diam., | 3-5 diam. long. |
| oog., | 36-42 μ " | 43-54 μ long. |
| oos., | 31-37 μ " | 33-39 μ " |
| nan. stipe, | 12-13 μ " | 24-33 μ " |
| anth. cell, | 9-10 μ " | 7-10 μ " |

Mass., Pa. *Europe.*

Var. AEMULANS Hirn, 1900, p. 235, Pl. XXXIX, fig. 242; *Oe. Lundense* Wolle, 1887, p. 79, Pl. LXXVII, figs. 9 and 10; Wittr., Nordst. and Lagerh., Alg. Exsicc., No. 1402. Somewhat smaller in all dimensions, as well as more variable; oogonia 2-6.

Pa., Cal. *So. America.*

From similar American species this is distinguished by the manner in which the operculum separates from the lower part of the oogonium; the parts are not parallel, but more as if hinged at one side and open at the other.

61. OE. LONGATUM Kützing, 1853, p. 11, Pl. XXXIII, fig. 6; Wolle, 1887, p. 95, Pl. LXXV, fig. 3; Hirn, 1900, p. 239, Pl. XL, fig. 248; P. B.-A., No. 812. Dioecious, nannandrous;

oogonia single or 2, more rarely 3, oviform or ellipsoid, operculate, division superior; oospore ellipsoid, about filling the oogonium, membrane sometimes very finely crenulate; suffultory cell similar to other vegetative cells; basal cell elongate, terminal cell obtuse; dwarf males on the oogonium; antheridium exterior, 1- (or more-) celled, curved.

| | | |
|---|---|---|
| veg. cell, | 4-7 μ diam., | 2-5 diam. long. |
| oog., | 16-18 μ " | 21-25 μ long. |
| oos., | 15-17 μ " | 17-19 μ " |
| nan. stipe, | 5-6 μ " | 10-15 μ " |
| anth. cell, | 4-5 μ " | 5-6 μ " |

Mass., Pa. *Europe.*

A very slender species, usually found as scattered filaments among other species of *Oedogonium*. The curved antheridia seem peculiar among the American species.

62. OE. ACROSPORUM De Bary, 1854, pp. 47, 60, 94, Pl. III, figs. 1-12; Hirn, 1900, p. 244, Pl. XLI, fig. 254; *Oe. acrosporum* var. *connectens* P. B.-A., No. 409. Dioecious, nannandrous, gynandrosporous (or idioandrosporous); oogonia single, terminal, ellipsoid, operculate, division near summit, operculum minute, deciduous; membrane of oogonium with longitudinal, sometimes anastomosing ridges on the inner surface; oospore quite filling the oogonium, the outer membrane with 23-30 longitudinal, very finely crenulate ridges, closely fitting between the ridges of the oogonium, and connected by delicate transverse striae; inner membrane smooth; suffultory cell somewhat swollen; basal cell elongate, terminal cell obtuse; androsporangia 1-2-celled, hypogynous; dwarf males curved, on the suffultory cell, stipe sometimes 2-3-celled, upper cells long, antheridium exterior, 1-2-celled.

| | | |
|---|---|---|
| veg. cell, | 13-21 μ diam., | 3-6 diam. long. |
| suf. cell, | 17-25 μ " | 1½-3 " " |
| oog., | 38-48 μ " | 50-63 μ long. |
| andr. cell, | 16-21 μ " | 12-15 μ " |
| lower cell, nan. stipe, | 9-12 μ " | 30-38 μ " |
| upper cell, nan. stipe, | 6-8 μ " | 55-71 μ " |
| anth. cell, | 6-8 μ " | 9-15 μ " |

Mass. *Europe, Asia, So. America.*

Our only species of *Oedogonium* in which each fertile filament bears one terminal oogonium, and none elsewhere.

Forma BOREALE (Wolle) Hirn, 1900, p. 245, Pl. XLI, fig. 256; *Oe. acrosporum* var. *boreale* Wolle, 1887, p. 84; Pl. LXXIX, figs. 10 and 11. Filaments of few cells, vegetative cells shorter than in the type, 14-16 $\mu$ diam., 3-5 diam. long.

N. J., Pa.

Probably a local form.

Var. FLORIDENSE Wolle, 1887, p. 83, Pl. LXXXV, figs. 1 and 2; Hirn, 1900, p. 246, Pl. XLI, fig. 258. A slender form, with long vegetative cells, suffultory cells more swollen than in the type; dwarf males very long, stipe 2-3-celled.

| | | |
|---|---|---|
| veg. cell, | 7-8 $\mu$ diam., | 5-11 diam. long. |
| oog., | 33-35 $\mu$ " | 45-50 $\mu$ diam. |

Florida.

Var. BATHMIDOSPORUM (Nordst.) Hirn, 1900, p. 246, Pl. XLII, fig. 259; *Oe. acrosporum*, P. B.-A., No. 163. Smaller, with fewer ridges on oogonium and oospore, about 11-17, distinctly crenate, with distinct striae between; stipe of dwarf male unicellular.

| | | |
|---|---|---|
| veg. cell, | 12-17 $\mu$ diam., | 3-8 diam. long. |
| suf. cell, | 15-22 $\mu$ " | 2½-5 " " |
| oog., | 30-40 $\mu$ " | 40-54 $\mu$ long. |
| nan. stipe, | 9-11 $\mu$ " | 9-12 $\mu$ " |

ANTHERIDIUM INTERIUS, PORIFERA, ELLIPSOSPORA.

63. OE. CYATHIGERUM Wittrock, 1870, p. 131, Pl. I, figs. 6 and 7; Hirn, 1900, p. 252, Pl. XLIII, fig. 265. Dioecious, nannandrous, idioandrosporous; oogonia single or 2-3, suboviform or quadrangular-ellipsoid, pore superior; oospore same form as the oogonium, filling it, membrane triple; outer membrane smooth, median membrane with 16-25 longitudinal, continuous, rarely anastomosing, often curved, ridges, inner membrane smooth; basal cell elongate, terminal cell, which sometimes is an oogonium, obtuse; dwarf males goblet-shaped, curved, on the suffultory cell, rarely on the oogonium; antheridium interior.

| | | |
|---|---|---|
| veg. cell, | 21-30 $\mu$ diam., | 2-10 diam. long. |
| suf. cell, | 42-48 $\mu$ " | 1¾-2½ " " |
| oog., | 57-66 $\mu$ " | 70-100 $\mu$ long. |
| oos., | 51-62 $\mu$ " | 60-75 $\mu$ " |
| anth. cell, | 23-30 $\mu$ " | 12-30 $\mu$ " |
| nan. cell, | 12-15 $\mu$ " | 50-58 $\mu$ " |

The type is European, and has not yet been found in this country. We have

Forma ORNATUM (Wittrock) Hirn, 1900, p. 254, Pl. XLIII, fig. 267; with longer dwarf males, 60-75 $\mu$, and slightly longer oospores; otherwise like the type.

Mexico.

Forma AMERICANUM Wolle, 1887, p. 77, Pl. LXXXI, figs. 20-22; Hirn, 1900, p. 256. More slender than the type, with shorter vegetative cells, and dwarf males on the oogonium, not on the suffultory cell.

| | | |
|---|---|---|
| veg. cell, | 17-21 $\mu$ diam., | 1¼-3 diam. long. |
| oog., | 45-50 $\mu$ " | 55-63 $\mu$ long. |
| oos., | 39-40 $\mu$ " | 44-46 $\mu$ " |
| nan. cell, | 12-15 $\mu$ " | 50-54 $\mu$ " |

Pa.

The long, goblet-like dwarf males are characteristic of this species, and have given it its specific name. The interior antheridium is often hard to distinguish, and the species was at first described as having unicellular antheridia. The dwarf males, with the much swollen suffultory cells, and the irregular lines on the oospore, make a combination of characters that clearly distinguishes the species, and this combination is found in all the forms and varieties.

ANTHERIDIUM INTERIUS, OPERCULATA.

64. OE. UNDULATUM (Bréb.) A. Braun in De Bary, 1854, p. 94; Wolle, 1887, p. 76, Pl. LXXVII, fig. 8; Hirn, 1900, p. 257, Pl. XLV, fig. 273; Wittr. and Nordst., Alg. Exsicc., No. 702, in part. Dioecious, nannandrous, gynandrosporous or idioandrosporous; oogonia single or 2, subglobose or ellipsoid-globose, operculate, division inferior, oospore globose or subglobose, almost filling the oogonium, membrane smooth, generally thick; suffultory cell not or only slightly swollen; androsporangia to 7-celled; vegetative cells four times undulate-constricted; basal cell elongate, not undulate; terminal cell, which sometimes is an oogonium, obtuse; dwarf males elongate-obconic, generally on the suffultory cell, more rarely on other vegetative cells near the oogonium; antheridium interior.

| | | |
|---|---|---|
| veg. cell, | 12-22 $\mu$ diam., | 3-5 diam. long. |
| oog., | 48-56 $\mu$ " | 50-75 $\mu$ long. |
| oos., | 42-50 $\mu$ " | 42-52 $\mu$ " |
| andr. cell, | 15-21 $\mu$ " | 7-14 $\mu$ " |
| nan. cell, | 8-10 $\mu$ " | 48-65 $\mu$ " |

*Europe, Australia, So. America.*

Reported by Wolle, but the only definite American locality recorded is Martha's Vineyard, Mass., and the plant there is

Forma SENEGALENSE (Nordst.) Hirn, 1900, p. 261, Pl. XLV, fig. 277; P. B.-A., No. 73. Oogonia and oospores somewhat smaller than in the type, dwarf males shorter; oogonia to 5-seriate; vegetative cells with the three median swellings repand, the terminal swellings entire.

| | | |
|---|---|---|
| veg. cell, | 15-22 μ diam., | 3-5 diam. long. |
| oog., | 42-52 μ " | 44-63 μ long. |
| oos., | 37-44 μ " | 36-44 μ " |
| andr. cell, | 15-19 μ " | 9-18 μ " |
| nan. cell, | 6-8 μ " | 37-44 μ " |

Mass. *Africa.*

The description and the measurements just given are founded on the specimens distributed in P. B.-A., No. 73; the original forma *senegalense* from Africa, has oogonia not over 3-seriate, and swellings of the vegetative cells entire. As with *Oe. cyathigerum*, so in this species the antheridia appear to be unicellular unless good material is carefully examined. The peculiar form of the vegetative cells easily distinguishes it from all our other species, *Oe. nodulosum* being the only other with similar constrictions, but there is no danger of confounding the two, if the constrictions are counted; these two are our only species which are recognizable even when sterile.

NANNANDRES UNICELLULARES; OPERCULATA, GLOBOSPORA.

65. OE. ROTHII (LeCl.) Pringsheim, 1858, p. 69, Pl. V, fig. 4; Hirn, 1900, p. 265, Pl. XLV, fig. 282; P. B.-A., No. 520. Dioecious, nannandrous, gynandrosporous; oogonia single or 2-3-seriate, subdepressed-globose, operculate, division median, narrow; oospore depressed-globose, almost filling the oogonium, membrane smooth; suffultory cell not swollen; androsporangia 1-4-celled, subhypogynous, hypogynous, subepigynous or scattered; dwarf males oboviform, unicellular, on the oogonium.

| | | |
|---|---|---|
| veg. cell, | 6-10 μ diam., | 3-8 diam. long. |
| oog., | 20-27 μ " | 16-27 μ long. |
| oos., | 17-25 μ " | 14-20 μ " |
| andr. cell, | 6-8 μ " | 5-10 μ " |
| nan. cell, | 4 μ " | 11-12 μ " |

Mass. *Europe.*

66. OE. DECIPIENS Wittrock, 1874, p. 18; Wolle, 1887, p. 75, Pl. LXXVII, figs. 5 and 6; Hirn, 1900, p, 266, Pl. XLVI, fig. 283; Wittr. and Nordst., Alg. Exsicc., No. 602, in part. Dioecious, nannandrous, gynandrosporous; oogonia single, or

2-3, subdepressed-globose, operculate, division median, rather narrow; oospore subdepressed or depressed-globose, almost filling the oogonium, membrane smooth; suffultory cell not swollen; androsporangia to 6-celled, subepigynous, hypogynous or scattered; dwarf males oboviform, unicellular, on the oogonium.

| | | |
|---|---|---|
| veg. cell, | 9-12 μ diam., | 3-5 diam. long. |
| oog., | 30-38 μ " | 27-40 μ long. |
| oos., | 25-34 μ " | 23-28 μ " |
| andr. cell, | 9-10 μ " | 8-15 μ " |
| nan. cell, | 6-7 μ " | 13-15 μ " |

N. J., Iowa. *Europe.*

Somewhat resembling *Oe. Rothii*, but a larger plant.

67. OE. ARESCHOUGII Wittrock, 1870, p. 122, Pl. I, figs. 1 and 2; Wolle, 1887, p. 76, Pl. LXXVII, fig. 7; Hirn, 1900, p. 270, Pl. XLVI, fig. 289. Dioecious, nannandrous, gynandrosporous; oogonia 2-6 or single, subdepressed- or depressed-pyriform-globose, operculate, division median, broad; oospore globose, rarely subdepressed-globose, not nearly filling the oogonium, membrane smooth; suffultory cell of the same form as the other vegetative cells; androsporangia 1-6-celled, subepigynous or hypogynous, or more rarely scattered; vegetative cells capitellate; basal cell elongate, terminal cell, which sometimes is an oogonium, obtuse; dwarf males oboviform, unicellular, on the oogonium.

| | | |
|---|---|---|
| veg. cell, | 8-13 μ diam., | 4-6 diam. long. |
| oog., | 34-39 μ " | 36-40 μ long. |
| oos., | 22-26 μ " | 22-25 μ " |
| andr. cell, | 9-11 μ " | 10-12 μ " |
| nan. cell, | 6-7 μ " | 13-15 μ " |

Greenland, N. J. *Europe, So. America.*

Forma ROBUSTUM Hirn, 1900, p. 271, Pl. XLVI, fig. 290. Idioandrosporous; larger in all parts than the type, especially as to the vegetative cells; oogonia to 8-seriate.

| | | |
|---|---|---|
| veg. cell, | 12-17 μ diam., | 3-6 diam. long. |
| oog., | 36-40 μ " | 36-53 μ long. |
| oos., | 30-32 μ " | 27-31 μ " |
| andr. cell, | 9-12 μ " | 10-13 μ " |
| nan. cell, | 6-8 μ " | 14-15 μ " |

*England.*

Hirn includes provisionally under this form the plant from Minnesota, distributed in Tilden, American Algae, No. 3, as

*Oe. obtruncatum* var. *oblatum* Tilden, though the dimensions vary somewhat, being

| | | |
|---|---|---|
| veg. cell, | 15-20 μ diam., | 1½-2½ diam. long. |
| oog., | 37-42 μ " | 35-38 μ long. |

68. OE. PLATYGYNUM Wittrock, 1872a, p. 1; Wolle, 1887, p. 75, Pl. LXXVII, figs. 1-4; Hirn, 1900, p. 276, Pl. XLVII, fig. 301; Wittr., Nordst. and Lagerh., Alg. Exsicc., No. 1218. Dioecious, nannandrous, gynandrosporous and idioandrosporous; oogonia single or very rarely 2, depressed-oboviform, with 7-12 rounded prominences arranged in a whorl around the middle, operculate, division inferior; oospore depressed- or subdepressed-globose, not quite filling the oogonium, membrane smooth; suffultory cell not or slightly swollen; androsporangia 1-3 celled; vegetative cells slightly capitellate, terminal cell obtuse; dwarf males unicellular, oboviform, very small, on the oogonium.

| | | |
|---|---|---|
| veg. cell, | 6-10 μ diam., | 2-5 diam. long. |
| oog., | 21-30 μ " | 16-24 μ long. |
| oos., | 17-24 μ " | 15-20 μ " |
| andr. cell, | 6-8 μ " | 7-8 μ " |
| nan. cell, | 4.5-5 μ " | 8.5-9.5 μ " |

N. J., Pa., Fla., Minn. *Europe, So. America.*

The peculiar form of the oogonium, with the whorl of projections, is not found in any other American species.

69. OE. PLUVIALE Nordstedt in Rabenhorst, Algen., No. 2257; Hirn, 1900, p. 280, Pl. XLVIII, fig. 311; P. B.-A., No. 1190. *Oe. fonticola* Wolle, 1887, p. 93, Pl. LXXV, figs. 4-6. Dioecious, nannandrous, idioandrosporous; oogonia single, very rarely 2-3, oboviform-globose or subglobose, operculate, division superior; oospore subglobose or subellipsoid-globose, almost filling the oogonium, membrane smooth; suffultory cell not swollen; vegetative cells varying much in diameter in the same individual; basal cell elongate, terminal cell obtuse; androsporangial plants often somewhat more slender than the female; androsporangia to 10-celled; dwarf males broadly oboviform, unicellular, on the oogonium.

| | | |
|---|---|---|
| veg. cell, female, | 22-29 μ diam., | ¾-2 diam. long. |
| veg. cell, male, | 18-27 μ " | 1-2 " " |
| oog., | 34-45 μ " | 34-50 μ long. |
| oos., | 32-40 μ " | 31-43 μ " |
| andr. cell, | 17-25 μ " | 6-13 μ " |
| nan. cell, | 10 μ " | 14-15 μ " |

Cal. *Europe.*

Wolle says frequent, but gives no definite locality. The considerable variation both in length and diameter of cells in the same plant, is quite noticeable.

SPECIES OF WHICH THE ORGANS OF FRUCTIFICATION ARE ONLY PARTLY KNOWN.

70. OE. GIGANTEUM Kützing, 1845, p. 200; Wolle, 1887, p. 94, Pl. LXXVI, figs. 1-6; Hirn, 1900, p. 295, Pl. XXIII, fig. 115; Phyk. Univ., No. 177. Oogonia single, slightly swollen, cylindric-oboviform, pore superior; oospore cylindric-ellipsoid or subellipsoid, nearly filling the oogonium, membrane apparently triple; outer membrane smooth, median with 25-30 longitudinal series of pits; inner membrane smooth; suffultory cell often larger than the other vegetative cells, but not swollen.

| | | |
|---|---|---|
| veg. cell, | 30-50 $\mu$ diam., | 2-4½ diam. long. |
| suf. cell, | 40-60 $\mu$ " | 1½-3½ " " |
| oog., | 53-69 $\mu$ " | 67-106 $\mu$ long. |
| oos., | 51-65 $\mu$ " | 65-103 $\mu$ " |

Mentioned by Wolle, but without exact locality; we have no other species with similar markings to the spore.

71. OE. PYRIFORME Wittrock, 1874, p. 39; Wolle, 1887, p. 95, Pl. LXXVII, figs. 11-13; Hirn, 1900, p. 303, Pl. XXV, fig. 137. Oogonia single, pyriform, operculate; antheridia 2-3-celled, subepigynous, hypogynous or scattered.

| | | |
|---|---|---|
| veg. cell, | 13-16 $\mu$ diam., | 3½-6 diam. long. |
| oog., | 40-45 $\mu$ " | 54-60 $\mu$ long. |
| ?anth. cell, | 10-12 $\mu$ " | 9-12 $\mu$ " |

N. J. *Australia.*

A very imperfectly known species; but the form of the oogonium is peculiar; pyriform, or perhaps better, "top-shaped."

72. OE. SANCTI THOMAE Wittrock and Cleve in Wittrock, 1874, p. 40; Hirn, 1900, p. 304, Pl. XXIX, fig. 173. Oogonia single or 2-3, pyriform, operculate, division superior; oospore pyriform-oboviform, not quite filling the oogonium, membrane smooth; basal cell subhemispherical, not elongate; terminal cell very slender, subhyaline.

| | | |
|---|---|---|
| veg. cell, | 7-15 $\mu$ diam., | 2-6 diam. long. |
| term. cell, | 2-4 $\mu$ " | 5-7 " " |
| oog., | 28-33 $\mu$ " | 36-50 $\mu$ long. |
| oos., | 25-30 $\mu$ " | 28-35 $\mu$ " |
| basal cell, | 14-23 $\mu$ " | 8-12 $\mu$ " |

St. Thomas, W. I.

Somewhat resembling *Oe. pyriforme*, but a smaller plant, and with peculiar basal and terminal cells.

73. OE. CATARACTUM Wolle, 1887, p. 77, Pl. LXXXV, figs. 10-12; Hirn, 1900, p. 308, Pl. XLII, fig. 264. Dioecious, nannandrous, idioandrosporous; oogonia single or 2, often terminal, oboviform-globose, subglobose or broadly ovate, pore superior; oospore globose or oboviform-globose, almost filling the oogonium; androsporangia 2-6-celled, dwarf males much curved, on suffultory cell or sometimes on the cell below this; antheridium interior?

| | | |
|---|---|---|
| veg. cell, | 28-38 μ diam., | 1½-3 diam. long. |
| oog., | 55-60 μ " | 60-75 μ long. |
| oos., | 50-55 μ " | 50-60 μ " |
| andr. cell, | 26-30 μ " | 10-15 μ " |
| nan. cell, | 10 μ " | 65 μ " |

Pa.

Although this description appears to be fairly complete, the species is placed by Hirn among those insufficiently known, as Wolle's statements in regard to the male plant are contradictory; this being given as unicellular and also as having internal antheridia. Hirn suggests that it may be a form of *Oe. crassiusculum*.

74. OE. LONDINENSE Wittrock, 1874, p. 39; Wolle, 1887, p. 94, Pl. LXXV, figs. 7 and 8; Hirn, 1900, p. 317. Oogonia 2 or 1, globose, division median, oospore globose, almost filling the oogonium; antheridia (or androsporangia?) 1-2-celled, hypogynous.

| | | |
|---|---|---|
| veg. cell, | 10-15 μ diam., | 1½-5 diam. long. |
| oog., | 33-35 μ " | 33-43 μ long. |
| oos., | 27-32 μ " | 27-32 μ " |
| anth. cell? | 12 μ " | 10-11 μ " |

N. J., according to Wolle. A very imperfectly known species, and American only with some doubt, there being no other record than Wolle's.

## 2. BULBOCHAETE Agardh, 1817, p. XXIX.

Filaments branching; vegetative cells increasing in size to upper end; basal cell often lobed, attached to substratum; terminal cell of each filament and branch produced into a long, hyaline seta with a bulbous base; plant increasing mostly by division of the basal cell of the principal filament or of a branch; oogonia arising by a double division of a vegetative cell.

There is no danger of mistaking a *Bulbochaete*, even in the sterile condition, for any other alga; the erect, branching frond, with cells larger at their top than at their bottom, and every branch ending in a long seta with a bulbous base, are unmistakable characters. In the determination of species much the same distinctions are used as in *Oedogonium*, and also characters drawn from the formation of the oogonium; as this arises by a double division of the vegetative cell, the suffultory cells are two, and according as the upper of the two is longer or shorter than the lower, or of the same length, we have the characters, dissepiment inferior, superior or median. If the two partition walls have formed directly across the axis of the original cell, we have oogonium erect; if one of them is oblique, giving one of the cells a five-angled appearance in section, we have oogonium patent.

The species of *Bulbochaete* are found in the same stations as *Oedogonium*, and though not so common as species of the latter, they are by no means infrequent, and are distributed all over the world.

KEY TO THE SPECIES OF BULBOCHAETE.

| | |
|---|---|
| 1. Spores globose. | 2. |
| 1. Spores ellipsoid. | 10. |
| 2. Oogonia erect. | 1. *B. Brebissonii.* |
| 2. Oogonia patent. | 3. |
| 3. Oogonia 60 $\mu$ diam. or more. | 4. |
| 3. Oogonia not over 56 $\mu$ diam. | 5. |
| 4. Gynandrosporous. | 8. *B. setigera.* |
| 4. Idioandrosporous. | 18. |
| 5. Oogonium biconic- or subquadrangular-globose. | 7. *B. angulosa.* |
| 5. Oogonium depressed- or subdepressed-globose. | 6. |
| 6. Dissepiment of suffultory cell about median. | 7. |
| 6. Dissepiment of suffultory cell superior. | 8. |
| 7. Membrane of oospore minutely crenulate. | 2. *B. intermedia.* |
| 7. Membrane of oospore strongly crenulate. | 3. *B. crenulata.* |
| 8. Oogonia 44-56 $\mu$ diam. | 6. *B. dispar.* |
| 8. Oogonia rarely equalling 46 $\mu$. | 9. |
| 9. Gynandrosporous. | 4. *B. Nordstedtii.* |
| 9. Idioandrosporous. | 5. *B. polyandria.* |
| 10. Monoecious. | 11. |
| 10. Dioecious. | 13. |

11. Vegetative cells about as long as broad, moniliform. 11. *B. monile.*
11. Vegetative cells longer than broad, subcylindrical. 12.
12. Oogonium 20-25 μ diam. 12. *B. nana.*
12. Oogonium 26-35 μ diam. 13. *B. mirabilis.*
13. Suffultory cell without dissepiment. 14. *B. pygmaea.*
13. Suffultory cell with dissepiment. 14.
14. Oogonium about 1½ times as long as broad. 15.
14. Oogonium about 1¾ times as long as broad or more. 19. *B. minor.*
15. Oogonium 26-39 μ diam. 16.
15. Oogonium 44-60 μ diam. 18. *B. insignis.*
16. Vegetative cells repand. 17. *B. repanda.*
16. Vegetative cells cylindrical. 17.
17. Cells rectangular in longitudinal section. 16. *B. rectangularis.*
17. Cells oval or subtriangular in longitudinal section. 15. *B. varians f. subsimplex.*
18. Dwarf males shorter than the oogonium. 9. *B. crassiuscula.*
18. Dwarf males longer than the oogonium. 10. *B. gigantea.*

GLOBOSPORAE.

1. B. BREBISSONII Kützing, 1855, p. 19, Pl. LXXXVI.B; Hirn, 1900, p. 323, Pl. LI, fig. 330; Rabenhorst, Algen, No. 1055. Dioecious, nannandrous, gynandrosporous; oogonia depressed-subquadrangular-globose, erect, below terminal setae or androsporangia; dissepiment of suffultory cell very low; epispore of oospore scrobiculate; androsporangia scattered or epigynous, 1-3-celled; dwarf males on oogonia, more rarely near them, antheridium interior, stipe slightly curved, shorter than the antheridium.

| | | |
|---|---|---|
| veg. cell, | 17-20 μ diam., | 3-4½ diam. long. |
| oog., | 42-50 μ " | 37-45 μ long. |
| andr. cell, | 11-15 μ " | 12-18 μ " |
| nan., | 10-12 μ " | 28-33 μ " |

Mass., Alaska. *Northern Europe.*

The only species with interior antheridium and erect oogonia.

2. B. INTERMEDIA De Bary, 1854, p. 72, Pl. IV, figs. 1-7; Wolle, 1887, p. 97, Pl. LXXXVI, figs. 1-3; Hirn, 1900, p. 326, Pl. LII, fig. 333; P. B.-A., No. 973. Dioecious, nannandrous, gynandrosporous; oogonia sub-depressed-globose, patent, below the androsporangia; dissepiment of suffultory cells about median; epispore of oospore pitted or more rarely smoothish; androsporangia 1-, rarely 2-celled, epigynous, more rarely scattered; dwarf males on oogonium; antheridium interior, stipe slightly curved, shorter than the antheridium. Fig. 82.

| | | |
|---|---|---|
| veg. cell, | 17-20 μ diam. | 2-3½ diam. long. |
| oog., | 40-48 μ " | 31-40 μ long. |
| andr. cell, | 11-13 μ " | 7-12 μ " |
| nan., | 9-10 μ " | 21-26 μ " |

Greenland, Conn., Pa., Alaska. *Europe, Australia.*

Forma SUPRAMEDIANA (Wittr.) Hirn, 1900, p. 328, Pl. LII, fig. 335; Wittr. and Nordst., Alg. Exsicc., No. 509, in part. Oogonia smaller, usually below the terminal setae; dissepiment of suffultory cells somewhat above the middle, rarely quite near the middle; androsporangia scattered.

| | | |
|---|---|---|
| veg. cell, | 17-20 μ diam., | 2-3 diam. long. |
| oog., | 40-45 μ " | 32-37 μ long. |
| anth. cell, | 11-12 μ " | 7-11 μ " |
| nan., | 9-10 μ " | 20-25 μ " |

Pa.

A common species and variable; the plants distributed as P. B.-A., No. 973, have vegetative cells and oogonia somewhat more slender than in the type.

3. B. CRENULATA Pringsheim, 1858, p. 72, Pl. VI, fig. 4; Wolle, 1887, p. 97, Pl. LXXXVI, fig. 4; Hirn, 1900, p. 331, Pl. LIII, fig. 337. Wittr. and Nordst., Alg. Exsicc., No. 602, in part. Dioecious, nannandrous, gynandrosporous; oogonia subdepressed-globose, patent, below the terminal setae or the androsporangia, rarely under vegetative cells; dissepiment of suffultory cells usually median or slightly lower; epispore of oospore distinctly pitted; androsporangia epigynous or scattered, 1-5-celled; dwarf males on oogonium or near it, antheridium interior, stipe slightly curved, shorter than the antheridium.

| | | |
|---|---|---|
| veg. cell, | 16-20 μ diam., | 2-3½ diam. long. |
| oog., | 43-48 μ " | 35-43 μ long. |
| anth. cell, | 10-15 μ " | 7-10 μ " |
| nan., | 9-10 μ " | 24-26 μ " |

*Europe, Australia.*

Quite doubtfully American, there being no authority other than Wolle's description and figures.

4. B. NORDSTEDTII Wittrock, 1874, p. 44; Hirn, 1900, p. 332, Pl. LIII, fig. 340; P. B.-A., No. 717. Dioecious, nannandrous, gynandrosporous; oogonia depressed sub-quadrangular-globose or depressed-globose, patent, below the androsporangia, or very rarely below the terminal setae; dissepiment of suffultory cells superior, rarely sub-median; epispore of oospore finely pitted or nearly smooth; androsporangia 1-celled, epigynous; dwarf males on oogonium; antheridium interior, stipe slightly curved, shorter than the antheridium.

| | | |
|---|---|---|
| veg. cell, | 14-17 μ diam., | 2-5 diam. long. |
| oog., | 36-43 μ " | 29-36 μ long. |
| andr. cell, | 10-12 μ " | 9-12 μ " |
| nan., | 9-10 μ " | 23-25 μ " |

Greenland, Conn., Alaska. *Europe, Australia.*

5. B. POLYANDRIA Cleve in Wittrock, 1870, p. 140; Wolle, 1887, p. 98, Pl. LXXXIX, figs. 6-9; Hirn, 1900, p. 334, Pl. LIV, fig. 342. Dioecious, nannandrous, idioandrosporous; oogonia subdepressed-globose, patent, under terminal setae or vegetative cells; dissepiment of suffultory cells superior, more rarely submedian; epispore of oospore finely pitted or nearly smooth; androsporangia 10-celled; dwarf males on oogonium; antheridium interior, stipe slightly curved, shorter than the antheridium.

| | | |
|---|---|---|
| veg. cell, | 15-20 μ diam., | 3-5 diam. long. |
| oog., | 39-46 μ " | 32-42 μ long. |
| andr. cell, | 12-14 μ " | 11-15 μ " |
| nan., | 8-9 μ " | 23-26 μ " |

Fla. *Europe, So. America.*

6. B. DISPAR Wittrock in Wittr. and Nordst., Alg. Exsicc., No. 401; Hirn, 1900, p. 335, Pl. LIV, fig. 334. Dioecious, nannandrous, gynandrosporous or idioandrosporous; oogonium large, subdepressed-globose, patent, under terminal setae, or more rarely under vegetative cells; dissepiment of suffultory cells superior, more rarely sub-median; membrane of oospore thick, epispore manifestly finely pitted; androsporangia scattered, 1-2-?-celled; dwarf males on oogonium; antheridium interior, stipe slightly curved, shorter than the antheridium.

| | | |
|---|---|---|
| veg. cell, | 16-21 μ diam., | 2-4½ diam. long. |
| oog., | 44-56 μ " | 42-51 μ long. |
| andr. cell, | 12-16 μ " | 10-12 μ " |
| nan., | 9-11 μ " | 23-36 μ " |

Greenland. *Sweden.*

7. B. ANGULOSA Wittrock and Lund in Wittrock, 1874, p. 45; Hirn, 1900, p. 336, Pl. LIV, fig. 346; *B. elachistandra* Wolle, 1887, p. 97, Pl. LXXXXVI, fig. 5. Dioecious, nannandrous, gynandrosporous; oogonia patent, biconic- or subquadrangular-globose, with truncate apex, sides of cone somewhat retuse, below terminal setae, or more rarely below androsporangia; dissepiment of suffultory cells a little above median; membrane of oospore smooth; androsporangia scattered or epigynous, 1-3-celled; dwarf males on oogonium, antheridium interior, stipe slightly curved, shorter than the antheridium.

| | | |
|---|---|---|
| veg. cell, | 13-18 μ diam., | 1½-2½ diam. long. |
| oog., | 36-42 μ " | 33-39 μ long. |
| andr. cell, | 10-11 μ " | 9-10 μ " |
| nan., | 8-9 μ " | 18-21 μ " |

*Europe, Africa.*

American only by Wolle's reference.

8. B. SETIGERA (Roth) Agardh, 1817, p. 71; Wolle, 1887, p. 98, Pl. LXXXVI, fig. 1; Wittr. and Nordst, Alg. Exsicc., No. 702; Hirn, 1900, p. 339, Pl. LV, fig. 351. Dioecious, nannandrous, gynandrosporous; oogonia sub-depressed- or depressed-quadrangular-globose, patent, generally below terminal setae, more rarely below androsporangia or vegetative cells; membrane of oospore thickened; dissepiment of suffultory cells usually slightly above median; epispore of oospore pitted; androsporangia scattered or more rarely epigynous, 1-3-celled; dwarf males on oogonium or near it; antheridium interior, stipe slightly curved, shorter than the antheridium.

| | | |
|---|---|---|
| veg. cell, | 25-28 μ diam., | 2½-5 diam. long. |
| oog., | 70-80 μ " | 56-65 μ long. |
| andr. cell, | 16-20 μ " | 10-18 μ " |
| nan., | 11-14 μ " | 30-36 μ " |

Conn., N. J., Fla., S. C. *Europe, So. America.*

*B. Canbyi* Wood, 1872, p. 202, Pl. XVI, fig. 6, is considered by Hirn to be included in this species.

9. B. CRASSIUSCULA Nordstedt, 1877, p. 30, Pl. III, figs. 14-15; Hirn, 1900, p. 341, Pl. LV, fig. 352; Wittr. and Nordst., Alg. Exsicc., No. 703. Dioecious, nannandrous, idioandrosporous; oogonia depressed-subquadrangular-globose, patent, below terminal setae or more rarely vegetative cells; dissepiment of suffultory cells superior, rarely submedian; epispore of oospore pitted; androsporangia 1-4-celled; dwarf males on oogonium or near it; antheridium interior, stipe slightly curved, shorter than the antheridium.

| | | |
|---|---|---|
| veg. cell, | 22-27 μ diam., | 2½-5½ diam. long. |
| oog., | 60-78 μ " | 50-62 μ long. |
| anth. cell, | 16-19 μ " | 10-13 μ " |
| nan., | 12-14 μ " | 30-34 μ " |

Greenland. *Europe, Australia.*

10. B. GIGANTEA Pringsheim, 1858, p. 71, Pl. VI, fig. 1; Wolle, 1887, p. 99, Pl. LXXXVII, fig. 1; Hirn, 1900, p. 347, Pl. LVII, fig. 359. Dioecious, nannandrous, idioandrosporous; oogonia sub-depressed-globose or depressed-oboviform-globose, patent, below terminal setae, rarely below vegetative cells; dis-

sepiment of suffultory cells submedian; epispore of oospore reticulately pitted; androsporangia 1-5-celled; dwarf males slightly longer than the oogonium, on the same; antheridium interior, stipe about twice as long as the antheridium, bent.

| | | |
|---|---|---|
| veg. cell, | 24-32 μ diam., | 2-3½ diam. long. |
| oog., | 60-70 μ " | 50-58 μ long. |
| andr. cell, | 18-20 μ " | 10-14 μ " |
| nan. stipe, | 10-13 μ " | 28-45 μ " |
| anth. cell, | 13-14 μ " | 20-30 μ " |

Pa. *Europe, Australia.*

ELLIPSOSPORAE.

11. B. MONILE Wittrock and Lund in Wittrock, 1874, p. 50; Hirn, 1900, p. 348, Pl. LVII, fig. 360; P. B.-A., No. 1432; *B. nana* Wolle, 1887, p. 100, Pl. LXXXVII, fig. 6. Monoecious, generally few-celled, vegetative cells short, hardly as long as broad, sides often convex, cells then submoniliform or subglobose; oogonia ellipsoid, patent or more rarely erect, below terminal setae or vegetative cells; antheridia 1-2-?-celled, erect or patent, subepigynous or scattered.

| | | |
|---|---|---|
| veg. cell, | 11-16 μ diam., | 1 diam. long. |
| oog., | 22-25 μ " | 30-37 μ long. |
| anth. cell, | 8-10 μ " | 6 8 μ " |

Mass., N. J. *Sweden.*

12. B. NANA Wittrock, 1872a, p. 7, Pl. I, fig. 9; Hirn, 1900, p. 349, Pl. LVII, fig. 362. Monoecious; oogonia ellipsoid, patent, below terminal setae or vegetative cells; antheridia 1-2-celled, erect, more rarely patent, subepigynous or scattered.

| | | |
|---|---|---|
| veg. cell, | 10-15 μ diam., | 1-1½ diam. long. |
| oog., | 20-25 μ " | 33-40 μ long. |
| anth. cell, | 7-9 μ " | 6-9 μ " |

Greenland, Alaska. *Europe.*

13. B. MIRABILIS Wittrock, 1870, p. 137, Pl. I, figs. 8 and 9; Wolle, 1887, p. 100, Pl. LXXXVII, figs. 2 and 3; Hirn, 1900, p. 351, Pl. LVIII, fig. 365; P. B.-A., No. 1431. Monoecious; oogonia ellipsoid or suboblong-ellipsoid, patent, or more rarely erect, below terminal setae or vegetative cells; antheridia 1-4-celled, erect or patent, subepigynous or scattered.

| | | |
|---|---|---|
| veg. cell, | 15-20 μ diam., | 1¼-2 diam. long. |
| oog., | 26-33 μ " | 46-58 μ long. |
| anth. cell, | 9-12 μ " | 6-9 μ " |

Greenland, N. J., Minn. *Europe, Australia.*

14. B. PYGMAEA Pringsheim, 1858, p. 74, Pl. VI, fig. 10; Wolle, 1887, p. 100, Pl. LXXXVII, figs. 4 and 5; Wittr. and Nordst., Alg. Exsicc., Nos. 4, 1401; Hirn, 1900, p. 356, Pl. LIX, fig. 372. Dioecious, nannandrous, gynandrosporous; vegetative cells short, not longer than wide; primary filament of the plant curved, short; oogonia ellipsoid, patent, below terminal setae or vegetative cells; suffultory cell without dissepiment; androsporangia subepigynous or scattered, 1-?-celled; dwarf males near oogonium, antheridium exterior, 1-3-celled.

| | | |
|---|---|---|
| veg. cell, | 11-15 $\mu$ diam., | $\frac{2}{3}$-1 diam. long. |
| oog., | 22-25 $\mu$ " | 32-40 $\mu$ long. |
| andr. cell, | 7-10 $\mu$ " | 6-9 $\mu$ " |
| nan. stipe, | 11-12 $\mu$ " | 15-19 $\mu$ " |
| anth. cell, | 7-8 $\mu$ " | 7-8 $\mu$ " |

*Europe.*

Only American authority Wolle's reference.

15. B. VARIANS var. SUBSIMPLEX (Wittr.) Hirn, 1900, p. 357, Pls. LIX, LX, fig. 374; *B. subsimplex* Wolle, 1887, p. 101, Pl. XC, fig. 5. Dioecious, nannandrous, gynandrosporous; oogonia ellipsoid, erect or more rarely patent, below terminal setae, androsporangia or vegetative cells; androsporangia scattered, epigynous or subepigynous, 1-2-?-celled; dwarf males near or on oogonium; antheridium exterior, 1-3-celled.

| | | |
|---|---|---|
| veg. cell, | 13-18 $\mu$ diam., | $1\frac{1}{4}$-$1\frac{3}{4}$ diam. long. |
| oog., | 26-30 $\mu$ " | 39-46 $\mu$ long. |
| andr. cell, | 10-14 $\mu$ " | 7-16 $\mu$ " |
| nan. stipe, | 11-14 $\mu$ " | 15-24 $\mu$ " |
| anth. cell, | 7-8 $\mu$ " | 5-7 $\mu$ " |

Pa. *Europe, Asia, Australia, So. America.*

The type with dimensions about one-fifth to one-fourth larger, and with oogonia more generally patent, is found only in Europe. *B. dumosa* Wood, 1872, p. 202, Pl. XVIII, fig. 6, according to Hirn should be included in this variety.

16. B. RECTANGULARIS Wittrock, 1870, p. 142; Wolle, 1887, p. 102, Pl. XC, fig. 1; Hirn, 1900, p. 359, Pl. LX, fig. 376; P. B.-A., No. 516. Dioecious, nannandrous, gynandrosporous; little branched, branches often very long; vegetative cells in cross section subrectangular; oogonia ellipsoid, patent or more rarely erect, below terminal setae or androsporangia, more rarely vegetative cells; androsporangia scattered or epigynous, 1-?-celled; dwarf males near oogonium or more rarely on it; antheridium exterior, 1-4-celled.

| | | |
|---|---|---|
| veg. cell, | 16-23 μ diam., | 1¼-2 diam. long. |
| oog., | 31-39 μ " | 45-63 μ long. |
| andr. cell, | 13-16 μ " | 10-27 μ " |
| nan. stipe, | 14-18 μ " | 22-27 μ " |
| anth. cell, | 8-10 μ " | 5-7 μ " |

Mass., R. I., Conn., Pa. *Europe.*

Var. HILOENSIS Nordstedt, 1878, p. 22; Wolle, 1887, p. 102, Pl. XC, figs. 2-3; Hirn, 1900, p. 361, Pl. LX, fig. 377. Smaller, vegetative cells longer, androsporangia generally epigynous, more rarely scattered.

| | | |
|---|---|---|
| veg. cell, | 14-19 μ diam., | 1¾-2½ diam. long. |
| oog., | 28-32 μ " | 47-51 μ long. |
| andr. cell, | 12-14 μ " | 13-16 μ " |
| nan. stipe, | 13-14 μ " | 22-24 μ " |
| anth. cell, | 8-9 μ " | 5-7 μ " |

*Australia.*

Wolle's reference is the only American report.

*B. rectangularis* and *B. varians* resemble each other considerably, but the latter is more branched and has shorter cells.

17. B. REPANDA Wittrock, 1874, p. 55; Wolle, 1887, p. 102, Pl. XC, fig. 4; Hirn, 1900, p. 363, Pl. LXI, fig. 380; P. B.-A., No. 814; *B. rhadinospora* Wolle, 1887, p. 103, Pl. LXXXIX, figs. 4 and 5. Dioecious, nannandrous, gynandrosporous; oogonia suboblong-ellipsoid, patent or erect, below androsporangia, terminal setae or vegetative cells; androsporangia epigynous or subepigynous, 1-?-celled; dwarf males near or on oogonium; antheridium exterior, 1-3-celled; vegetative cells sometimes repand.

| | | |
|---|---|---|
| veg. cell, | 12-17 μ diam., | 2-3½ diam long. |
| oog., | 26-36 μ " | 43-58 μ long. |
| andr. cell, | 13-15 μ " | 16-21 μ " |
| nan. stipe, | 11-15 μ " | 21-27 μ " |
| anth. cell, | 7-10 μ " | 5-7 μ " |

Greenland, Mass., Me., N. J., Fla. *Europe.*

18. B. INSIGNIS Pringsheim, 1858, p. 73, Pl. VI, fig. 7; Wolle, 1887, p. 101, Pl. LXXXVIII, figs. 2 and 3; Hirn, 1900, p. 364, Pl. LXII, fig. 383; P. B.-A., Nos. 1332, 1430. Dioecious, nannandrous, gynandrosporous; oogonia ellipsoid, erect or patent, below androsporangia, terminal setae or vegetative cells; androsporangia epigynous or subepigynous, more rarely scattered, 1-?-celled; dwarf males near or on oogonium; antheridium exterior, 1-3-celled.

| | | |
|---|---|---|
| veg. cell, | 19-25 μ diam., | 2½-3½ diam. long. |
| oog., | 46-56 μ " | 70-90 μ long. |
| andr. cell, | 16-20 μ " | 9-25 μ " |
| nan. stipe, | 16-19 μ " | 29-33 μ " |
| anth. cell, | 10-13 μ " | 7-10 μ " |

Mass., N. J., Alaska. *Europe, Australia.*

Var. RETICULATA (Nordst.) Hirn, 1900, p. 365, Pl. LXII, fig. 384. Epispore reticulate-denticulate, with doubly dentate longitudinal ridges, the teeth united to each other by transverse ridges; the longitudinal ridges more or less wavy and crooked, sometimes anastomosing; dimensions about the same as in the type.

The netted surface above described is sometimes found, bu exceptionally and in less degree, on oospores of the type; the variety merely has it more marked and more generally.

Mass. *Europe.*

19. B. MINOR A. Braun in Kützing, 1849, p. 422; Wolle, 1887, p. 101, Pl. LXXXVII, fig. 7; Hirn, 1900, p. 369, Pl. LXIII, fig. 390. Dioecious, nannandrous, gynandrosporous; oogonia suboblong-ellipsoid, erect or more rarely patent, below terminal setae, androsporangia, or more rarely vegetative cells; androsporangia epigynous, subepigynous or scattered, 1-?-celled; dwarf males near or on the oogonium; antheridium exterior, 1-4-celled.

| | | |
|---|---|---|
| veg. cell, | 18-25 μ diam., | 1½-2 diam. long. |
| oog., | 32-42 μ " | 59-69 μ long. |
| andr. cell, | 15-16 μ " | 16-21 μ " |
| nan. stipe, | 12-15 μ " | 22-24 μ " |
| anth. cell, | 6-10 μ " | 6-7 μ " |

N. J. *Sweden.*

## Family 6. CHAETOPHORACEAE.

Fronds filamentous, except in a few doubtful forms, usually much branched, sometimes united in disk-like expansions; cells uninucleate, with band- or disk-shaped chromatophore, often somewhat divided or with projections; with one, rarely more pyrenoids; hairs almost always present, but varying in character; asexual reproduction by 4-ciliate, in some cases biciliate zoöspores, by aplanospores, akinetes, and with special Palmella and Schizomeris stages in many genera; sexual reproduction in many genera by gametes similar to the zoospores.

This family includes both fresh water and marine forms, but the larger part is fresh water. There is a great range in differentiation between the extreme forms, and some forms are included here which have little resemblance to the more typical genera, but for which no more appropriate place could be found.

KEY TO THE GENERA OF CHAETOPHORACEAE.

1. Fronds erect with differentiated base and apex. 2.
1. Fronds creeping or expanded, no differentiated base and apex. 5.
2. Fronds less than 1 mm. high, tips not acute nor setiferous. 22. MICROTHAMNION.
2. Fronds larger, tips generally acute or setiferous. 3.
3. Filaments united in gelatinous thalli of definite form. 23. CHAETOPHORA.
3. Filaments practically free. 4.
4. Fascicled ramuli different in character from stem. 25. DRAPARNALDIA.
4. Stem, branches and ramuli little differentiated. 24. STIGEOCLONIUM.
5. Filaments originally creeping, producing short, erect branches, closely packed into a thin layer. 6.
5. No dense layer of vertical filaments distinct from basal layer. 8.
6. Fresh water. 7.
6. Marine. 21. PILINIA.
7. Cells of filaments seldom over 10 $\mu$ diam.; sporangia little if any larger than vegetative cells. 20. CHLOROTYLIUM.
7. Cells of filaments seldom under 20 $\mu$ diam.; fructification in swollen terminal cells. 19. GONGROSIRA.
8. Filaments more or less united laterally. 9.
8. Filaments not united. 18.
9. Forming an irregular loose incrustation. 9. PSEUDENDOCLONIUM.
9. Forming a definite disk. 10.
10. Disk monostromatic. 11.
10. Disk polystromatic. 14.
11. Setae or hairs more or less abundant. 12.
11. No setae or hairs. 13.
12. Radiating filaments turning up at the end. 10. ENDOCLONIUM.
12. Radiating filaments not turning up at the end. 15. OCHLOCHAETE.
13. Disk formed by filaments radiating from a center. 14. PRINGSHEIMIA.
13. Disk formed by the union of irregular filaments. 13. EPICLADIA.
14. Setae or hairs present. 16.
14. No setae or hairs. 15.
15. On shells of turtles. 11. DERMATOPHYTON.
15. On algae, stones, etc.; marine. 12. ULVELLA.
16. Hairs gelatinous. 16. CHAETOPELTIS.
16. Setae not gelatinous. 17.

17. Setae articulate. 18. ARTHROCHAETE.
17. Setae inarticulate. 17. CHAETOBOLUS.
18. Cells solitary. 1. DIPLOCHAETE.
18. Cells united in filaments. 19.
19. Epiphytic or in loose tissue of other algae. 20.
19. Living in the membrane of other algae or in outer coating of mollusks. 24.
20. Fresh water. 4. CHAETOSPHAERIDIUM.
20. Marine. 21.
21. Setae present. 22.
21. No setae. 23.
22. Setae arising from the ends of upright cells. 5. ACROCHAETE.
22. Setae arising from small special cells. 8. BOLBOCOLEON.
23. Basal network with short vertical branches. 7. PSEUDODICTYON.
23. Branching irregular, no definite network. 6. ENDOPHYTON.
24. In cell wall of algae. 2. ENDODERMA.
24. In outer coating of mollusk shells. 3. TELLAMIA.

In addition to the genera given in the foregoing key, there are a few others which may be reduced or rudimentary forms belonging to this family; the cells have the same structure, some species at least produce zoospores and aplanospores, and all have regular vegetative cell-division; there seems to be no better place for them.

1. Cells in older plants borne on stalks formed from the cell wall. 27. UROCOCCUS.
1. Cells never stalked. 2.
2. Cells dividing and soon separating, or forming small irregular masses or short filaments. 26. PLEUROCOCCUS.
2. Cell wall persisting and enclosing walls of later generations. 3.
3. Division in one direction. 28. DACTYLOTHECE.
3. Division in two or three directions. 4.
4. Families encircled by one or more opaque bands. 31. GLOEOTAENIUM.
4. No opaque bands. 5.
5. Families spherical or irregular. 6.
5. Families united into subcylindrical, branching thalli. 32. PALMODICTYON.
6. Families enclosed in a spherical, gelatinous envelop. 30. GLOIOCOCCUS.
6. Families with no general envelop. 29. GLOEOCYSTIS.

## 1. DIPLOCHAETE Collins, 1901, p. 242.

Cells solitary or a few united into a gelatinous, subfilamentous series, globose, flattened, ellipsoid or ovoid, furnished with two or more long, simple, sheathless setae; chromatophore single, parietal (with pyrenoid?). Reproduction unknown.

D. SOLITARIA Collins, 1901, p. 242. Epiphytic; cells 25-30 $\mu$ diam., with wall 5-8 $\mu$ thick, little or not at all lamellose; setae two, arising from the lower half of the cell, usually opposite, straight, tapering, 4-6 $\mu$ thick at base. Fig. 99. On *Laurencia obtusa*, Jamaica.

W. and G. S. West published, 1903, p. 79, *Polychaetophora* gen. n. Thallus minute, of few cells, filamentous, or sometimes unicellular; cells subglobose, ellipsoid or ovoid, membrane very thick and strongly lamellate; each cell furnished with 8-12 long, flexuous, simple, sheathless setae; chromatophore single, parietal, often indistinct (with one pyrenoid?). *P. lamellosa* sp. unica, Pl. CCCCXLVIII, figs. 1-4. Characters of the genus. This seems to be quite distinct from *Diplochaete*, but G. S. West, 1908, p. 279, Pl. XX, figs. 1-6, published *Polychaetophora simplex* sp. n. Cells subglobose or ovoid, membrane thin and homogeneous; dorsal part of each cell furnished with 2-4 long, flexuous, simple, sheathless setae. If the genus be extended so as to include this species, it would certainly include *Diplochaete solitaria*, and as the genus *Diplochaete* has priority, that name must be used. It is unfortunate that a more appropriate name should have to give place to one less appropriate to most of the species, but there seems to be no other course available than to revise the original description of *Diplochaete*, and to include the two British species of the Wests as **D. lamellosa** (W. and G. S. West) Collins nov. comb., and **D. simplex** (G. S. West) Collins nov. comb.

## 2. ENDODERMA Lagerheim, 1883, p. 74.

Frond microscopic, creeping on or within other algae or aquatic plants; filaments irregularly branched, with or without hairs; cell division mostly terminal; chromatophore a parietal layer with one or more pyrenoids; zoospores 2-4-ciliate, with stigma, formed 4 or more in a cell, escaping by a hole and soon germinating; asexual reproduction by biciliate zoogametes without stigma is probable, but not certain.

A genus of a few species, marine and fresh water; ours all with one pyrenoid and without hairs.

KEY TO THE SPECIES OF ENDODERMA.

| | |
|---|---|
| 1. Endophytic, marine. | 2. |
| 1. Epiphytic, fresh water. | 4. |
| 2. In leaves of Zostera. | 3. *E. perforans.* |
| 2. In marine algae. | 3. |
| 3. Cells averaging 9 $\mu$ diam., cylindrical. | 1. *E. Wittrockii.* |
| 3. Cells averaging 6 $\mu$ diam., irregular. | 2. *E. viride.* |
| 4. Cells subglobose to ellipsoid. | 4. *E. Pithophorae.* |
| 4. Cells much flattened. | 5. *E. polymorphum.* |

1. E. WITTROCKII (Wille) Lagerheim, 1883, p. 75; Hazen, 1902, p. 226, Pl. XLII, fig. 1; P. B.-A., Nos. 265, 1469. Filaments simple or irregularly branched, with tapering ends; branches sometimes united laterally; cells cylindrical, 5-10 $\mu$, usually 9 $\mu$ diam., 1-1½ diam. long, with one pyrenoid; growing in the cell walls of brown, less commonly of red algae; reproduction little known. Fig. 100. Me. to Conn. *Europe.*

Probably common in summer and autumn, but easily overlooked, as there is seldom anything in the appearance of the host to indicate the presence of the endophyte. It has been found most frequently in *Elachista fucicola*, but occurs in other algae; at times it is quite common in *Desmotrichum undulatum.*

2. E. VIRIDE (Reinke) Lagerheim, 1883, p. 74; *Entocladia viridis* Reinke, 1879, p. 476, Pl. VI. Filaments usually much branched, 3-8 $\mu$, usually 6 $\mu$ diam., cells 1-6 diam. long, sometimes cylindrical, oftener irregularly swollen and contorted, with one pyrenoid; terminal cell blunt or tapering; growing in cell walls of various algae. Mass. *Europe.*

A smaller plant than the preceding, and with more irregular branching. In Europe it has a more southern range than *E. Wittrockii*, and it is to be expected in localities south of Cape Cod.

3. E. PERFORANS Huber, 1892, p. 316, Pl. XIV. Filaments 3-5 $\mu$ diam., endophytic in the dead leaves of *Zostera marina;* cells more or less irregular in form and of varying length, with one pyrenoid; larger, rounded cells formed here and there, up to 14 $\mu$ diam; asexual reproduction by ovoid or subspherical 4-ciliate zoospores with stigma, formed in the larger cells, 8 in a cell. Me., Mass. *Europe.*

The slender filaments creep among the epidermis cells of the host, while the larger cells and sporangia are formed within the large cells of the inner layer of the *Zostera.* The zoospore comes to rest on the surface of a *Zostera* leaf and emits a tube which penetrates the outer layer of the host, and begins to branch almost immediately. The species is probably to be found everywhere in the dead and faded *Zostera* leaves in marsh pools.

4. E. PITHOPHORAE West, 1905, p. 283. Epiphytic; filaments not over 200 μ long, irregularly branched, branches attenuate, more or less concrete; cells 25-38 μ diam., subglobose, ellipsoid, ovoid, or oblong; apical cell 10-16 μ diam.; cell with one pyrenoid, membrane 3-4 μ thick. Barbados.

This species was found growing on *Pithophora Cleveana*, on or in the immediate vicinity of the intercalary spores; like the following species it is not at all endophytic, and thus connects *Endoderma* with *Epicladia*, but the filaments do not unite to form a definite disk.

5. E. POLYMORPHUM West, 1905, p. 283, Pl. CCCCLXIV, fig. 19. Epiphytic; filaments up to 250 μ long, irregularly branching and anastomosing; cells flattened, polymorphous, very irregular in form, 15-39×6-20 μ; thickness of membrane 3-7.5 μ; cell with one pyrenoid. Barbados.

This species occurs on the same host as *E. Pithophorae*, but on vegetative cells only; the flattened cells, with very irregular outline, seem to distinguish it from its companion.

### 3. TELLAMIA Batters, 1895, p. 315.

Frond of radiating, irregularly branched filaments, creeping in the periostracum of mollusca; parietal chromatophore nearly filling the cell, with one pyrenoid; cells often swollen; asexual reproduction by zoospores, formed in slightly swollen cells.

The two known species occur often in company, in the outer skin of the shells of Littorina, forming a more or less dense network, but not penetrating the shell itself. The color of the shells they inhabit is changed from bright yellow to some shade of dull yellow or brown.

T. CONTORTA Batters, 1895, p. 316, Pl. XI, figs. 18-24. Filaments yellowish green or brown, densely and irregularly branched; cells 6-9×3-10 μ, ovoid or ellipsoid; branching of two kinds, horizontal, similar to the main filament, branches sometimes falcate or coiled, often anastomosing; vertical, branches short, often united laterally, with acute terminal cells; inflated cells, up to 20 μ diam., occasionally occurring in the horizontal branches. Figs. 111, 112. On *Littorina palliata* Gould. Southern Mass. *England.*

The irregularly and densely branched fronds form an open or almost continuous layer in the membrane, sending short branches up and down, to the outer surface of the membrane, or to the surface of the shell. In England it is generally accompanied by the other species, *T. intricata* Batters, with more cylindrical cells and looser branching; this species has not yet been noticed in this country.

4. CHAETOSPHAERIDIUM Klebahn, 1891, p. 7.

Frond microscopic, epiphytic on various algae; cells globose or hemispherical, with disk-shaped chromatophore and one pyrenoid, bearing above a very long, delicate sheathed hair; cells dividing by a horizontal wall, the daughter cell then passing to the side of the mother cell, or emitting a tubular projection, at the end of which is formed a new setiferous cell; reproduction by motile spores, but character and development unknown. When a setiferous cell has divided and formed a tube, the contents of the lower (daughter) cell passes through the tube to the new cell; the tube either disappears as in *C. globosum*, or remains an empty utricle as in *C. Pringsheimii*.

KEY TO THE SPECIES OF CHAETOSPHAERIDIUM.

1. Utricles short and evanescent; general gelatinous envelop present. 1. *C. globosum*.
1. Utricles well developed; no general gelatinous envelop. 2. *C. Pringsheimii*.

1. C. GLOBOSUM (Nordst.) Klebahn, 1893, p. 306, Pl. XIV, figs. 5-10; Hazen, 1902, p. 229. *Aphanochaete globosa* Wolle, 1887, p. 119, Pl. CV, fig. 5. Cells 12-18 $\mu$ diam., sheath 16-17 $\mu$ long, 2-3 $\mu$ diam.; cells closely set, utricles inconspicuous, general gelatinous coating ample. On algae, chiefly *Oedogonium*. N. H. to N. J., Neb. *Europe*.

2. C. PRINGSHEIMII Klebahn, 1891, p. 7; 1892, p. 268, Pl. IV. Cells 9-12 $\mu$ diam., sheaths 13-18 $\mu$ long, about 2 $\mu$ diam.; cells united by well developed, persistent utricles into creeping filaments, sometimes with erect ends; no general gelatinous coating. On algae, chiefly *Coleochaete*. Fig. 104. Canada, near Lake Superior. *Europe*.

There may be some doubt whether the plant figured by Hazen, 1902, Pl. XLII, figs. 3 and 4, is really *C. Pringsheimii*, as stated, or a form of *C. globosum*; a comparison of this plate with Klebahn's plate would seem to indicate that they were not the same species.

5. ACROCHAETE Pringsheim, 1862, p. 1.

Epiphytic or endophytic; filaments creeping, branching, articulate, bearing short erect branches, which often end in a slender tube containing a long, slender seta; chromatophore parietal, with one or more pyrenoids; sporangia formed from terminal cells of erect branches, bearing no setae, producing many biciliate zoospores, which germinate to produce the parent form; sexual reproduction reported, but uncertain. Marine.

KEY TO THE SPECIES OF ACROCHAETE.

| | |
|---|---|
| 1. Cells seldom 2 diam. long. | 2. *A. parasitica.* |
| 1. Cells longer, 2-6 diam. | 1. *A. repens.* |

1. A. REPENS Pringsheim, 1862, p. 2, Pl. II; P. B.-A., No. 1279. Creeping filaments 7-9 μ diam., cells 2-6 diam. long, usually with several pyrenoids; sporangia elongate-ovoid, 8-12 ×20-40 μ. Fig. 101. In the cortical layer of *Chorda filum*, *Laminaria*, etc. Mass. *Europe.*

The setae are sometimes very abundant in this species, sometimes so rare that a careful examination is needed to find any.

2. A. PARASITICA Oltmanns, 1894, p. 208, Pl. VII, figs. 1-10; Rosenvinge, 1898, p. 114. Creeping filaments 8-12 μ diam., cells about 1½ diam. long, with disk-shaped chromatophore and one pyrenoid; sporangia somewhat clavate, usually projecting above the surface of the host plant, about 25×10-12 μ. In old fronds of *Fucus*. Greenland. *Europe.*

6. ENDOPHYTON Gardner, 1909, p. 371.

Filaments endophytic in red algae, sparingly and irregularly branched in the medulla of the host, more freely near the surface; cells with band-shaped chromatophore and one pyrenoid; sporangia at the surface of the host, on short erect branches, producing pyriform, biciliate zoospores.

E. RAMOSUM Gardner, 1909, p. 372, Pl. XIV, figs. 3 and 4. Filaments 4-6 μ diam., often tortuous and irregular, cells 6-8 diam. long; sporangia clavate, 10-12 μ diam., pointed when young; zoospores numerous, 3 μ diam., escaping by an opening at the end of the sporangium. Fig. 121. In fronds of *Iridaea laminarioides* Bory, *Gigartina radula* (Esper) J. Ag. Cal.

Forming patches usually a few mm. diam., but which may be confluent and cover considerable areas, usually near the base of the frond of the host. In *Gigartina* the patches show more reddish than the rest of the frond.

7. PSEUDODICTYON Gardner, 1909, p. 374.

Filaments endophytic in larger algae, much branched, long and tortuous, the branches at right angles, forming a network among the cells of the host; short branches arising from the cells of the network, the terminal cell of each branch developing into a sporangium at the surface of the host. Cells with parietal chromatophore and one large pyrenoid.

Evidently nearly related to *Endophyton*, but there is a sharper differentiation between the two parts of the frond, the definite horizontal network, and the short fruiting branches. The network has a superficial resemblance to *Microdictyon*, but the resemblance is probably only superficial.

P. GENICULATUM Gardner, 1909, p. 374, Pl. XIV, figs. 5 and 6. Young cells 3-4 μ diam., becoming larger with age; vertical branches of 2-3 cells arising from practically all the cells of the network; sporangia 8-12 μ diam. Fig. 120. In the cortical layer of *Laminaria Sinclairii*, near San Francisco, Cal.

The patent branches of the main filaments usually reach to a neighboring filament, thus forming a network with subrectangular meshes, each enclosing 4-8 cells of the host: from this network arise vertically short branches reaching to the surface of the host and terminating in sporangia with rounded ends; the nature of the reproductive bodies formed in these sporangia is not known. The plant is found chiefly in the terminal part of the blade of the host.

8. BOLBOCOLEON Pringsheim, 1862, p. 1.

Frond microscopic, epi- or endophytic in various algae; filaments creeping, branching, consisting of irregular rounded cells, on the upper (outer) side of which are borne smaller bulb-shaped cells, prolonged into a tube, from which projects a long, slender hair; chromatophore in the filament cells a parietal perforate layer with 5-10 pyrenoids; in the piliferous cells an irregularly toothed plate with two pyrenoids. Reproduction by biciliate zoospores, produced in large numbers in the filament cells; whether sexual or asexual is not known. Only one species.

B. PILIFERUM Pringsheim, 1862, p. 8, Pl. I; Farlow, 1881, p. 57; Hazen, 1902, p. 227; P. B.-A., No. 1225. Vegetative cells 12-16 μ diam., 2-3 diam. long. Fig. 108. Newfoundland to R. I.; California. *Europe.*

Not uncommon in summer and autumn in various loose-tissued marine algae, seldom in such quantity as to be noticeable without microscopic examination, but occasionally occurring in such quantity as to give a whitish appearance to algae normally brown. The circumstances favorable to its development favor also other small epiphytes, and it is usually accompanied by *Calothrix parasitica*, *Streblonema* species, etc. It is usually found in brown algae, *Leathesia difformis*, *Castagnea virescens*, *Mesogloia divaricata*, *Ralfsia Borneti*, etc.; sometimes in old plants of *Dictyosiphon* and *Scytosiphon*, where the normally compact cortical layer has become loose; occasionally in red algae such as *Nemalion multifidum* and *N. Andersonii*.

9. PSEUDENDOCLONIUM Wille, 1901, p. 29.

Frond of much and irregularly branched filaments, packed together in an irregular layer, with short, erect branches, and with very short rhizoids; cells of irregularly rounded shape; chromatophore a small parietal disk with one pyrenoid. Asexual reproduction by akinetes, and by 4-ciliate zoospores without stigma.

Only one species.

P. SUBMARINUM Wille, 1901, p. 29, Pl. III, figs. 101-134; P. B.-A., No. 1124. Cells 6-7 $\mu$ diam., forming a pseudoparenchymatous layer on the surface of and penetrating more or less into the substance of woodwork, near high water mark; akinetes of two types, one with wall little thickened, germinating at once; the other with thick walls and remaining in the resting state for some time; zoosporangia slightly larger than the vegetative cells, producing each 4-8 4-ciliate zoospores, about 4 $\mu$ diam., escaping by a short neck; germinating immediately. Fig. 87. Me., Mass., R. I. *Europe.*

This species forms a fine green granular coating on shaded woodwork near high water mark, and in appearance much resembles the common *Pleurococcus vulgaris*; but is distinctly filamentous, and appears to be a reduced form belonging to the Chaetophoraceae.

10. ENDOCLONIUM Szymanski, 1878, p. 18.

Frond endo- or epiphytic, forming larger or smaller disks, filaments erect at the margin, and here and there in the disk, forming erect, branching tufts. Asexual reproductiou by akinetes, and by small biciliate and larger 4-ciliate zoospores, with red stigma, formed one to several in a cell; sexual reproduction by small biciliate gametes.

A genus of minute plants inhabiting the leaves of various aquatic plants, probably closely allied to *Stigeoclonium*. We have only one species, and that somewhat doubtful, details of development and reproduction being insufficiently known.

E. ? MOEBIUSIANUM De Toni, 1889, p. 208 ; *Stigeoclonium* sp., Möbius, 1888, p. 239, Pl. IX, fig. 3. Disk up to 500 $\mu$ diam., composed of filaments radiating from a common center ; cells 5 $\mu$ diam., 1-2 diam. long ; rising above into a short, papilla-like extension ; occasionally seta-bearing. Fig. 88. Porto Rico.

The erect filaments are much less developed than in most species of the genus ; Möbius' first supposition may be correct, that it is a species or state of growth of *Stigeoclonium*.

### 11. DERMATOPHYTON Peter, 1886, p. 191.

Forming rounded or irregular disks, on the shells of turtles, of closely packed cells in several layers, below sending cuneiform projections into the shell ; asexual reproduction by (biciliate ?) zoospores formed by repeated division of the contents of the enlarged cells of the outer layer.

Only one species.

D. RADIANS Peter, 1886, p. 191 ; *D. radicans* Potter, 1887, p. 251, Pl. VIII. Disks up to 12 mm. diam., composed of squarish cells, originally in branching radial series, but soon united to a parenchymatous layer, several cells thick, except at the margin; the superficial cells enlarging to form sporangia, from which the contents are discharged in the form of zoospores, the cells below then becoming sporangia, the thickness of the frond being maintained by successive divisions of the cells by horizontal planes. Fig. 93. Mass. *Europe.*

The name is wrongly quoted by Potter as *D. radicans*, and the error has been copied by De Toni, 1889, Wille, 1900, and others ; no one seems to have taken the trouble to look up the original description.

### 12. ULVELLA Crouan, 1859, p. 288.

Fronds forming small disks on larger plants or other objects, firmly attached by the under surface, originally monostromatic, of radiating, laterally united, dichotomous filaments ; later polystromatic, except at the margin ; cells with parietal chromatophore and one pyrenoid, arranged in more or less definite vertical series ; biciliate zoospores formed in the central cells, 4-8-16 in a cell, escaping by an opening at the top. Marine.

KEY TO THE SPECIES OF ULVELLA.

| | |
|---|---|
| 1. On stones and shells. | 3. *U. lens.* |
| 1. On algae. | 2. |

2. Strictly epiphytic. 4. *U. prostrata.*
2. Penetrating the host more or less. 3.
3. Gelatinous, up to 75 $\mu$ thick, not confluent. 2. *U. fucicola.*
3. Not gelatinous, up to 250 $\mu$ thick, confluent. 1. *U. confluens.*

1. U. CONFLUENS Rosenvinge, 1893, p. 924, fig. 39. Forming green, confluent incrustations on old stipes of *Laminaria longicruris*: when mature, to 250 $\mu$ thick, smooth, composed of more or less regular, closely united, vertical filaments, diverging towards the margin; cells 10-12 $\mu$ diam., 2-4 diam. long, the disk- or cap-shaped chromatophore at the top; dissepiments horizontal or oblique, somewhat curved upward; terminal cells of the same size and form as the others, but with rounded top and richer contents: sporangia formed from the superficial cells, little changed in form or size, but with tip more acute: zoospores 30-40 in a cell, escaping by a terminal opening. Greenland. *Northern Europe.*

At first this plant is monostromatic, resembling a *Pringsheimia*, and even in this state produces spores. It continues to increase in thickness, and empty sporangial cells may be found quite a distance below the surface; from the lower surface short filaments penetrate the host plant to a greater or less depth.

2. U. FUCICOLA Rosenvinge, 1893, p. 926, fig. 40; Oltmanns, 1894, p. 211, Pl. VII, figs. 11-13. Frond pulvinate or hemispherical, to 75 $\mu$ thick, somewhat gelatinous, composed of oblong cells arranged in more or less distinctly radiating series; cells 5-7 $\mu$ diam., 3-5 diam. long, wall not sharply marked off from the general gelatinous coating; chromatophore parietal, occupying the middle part of the cell; all cells, except perhaps the basal layer, developing into sporangia, which swell to twice the size of the vegetative cells, and are pushed out from among them; zoospores 6-10 in a sporangium. On old plants of *Fucus*. Greenland. *Northern Europe.*

Quite different both in habit and structure from *U. confluens*, forming smaller, not confluent, more gelatinous fronds, with smaller cells, and less sharply differentiated sporangial layer. It penetrates the host plant, but not to such an extent as *U. confluens*.

3. U. LENS Crouan, 1859, p. 288, Pl. XXII, fig. E. Fronds orbicular, 1-3 mm. diam., cells 15-20 $\mu$ diam. in center of frond, near the margin 10-15 $\times$ 20-30 $\mu$; frond usually not over three layers thick in the center of the frond. Fig. 102. North Carolina, on stones and shells. *Europe.*

Though this is the original species of the genus, the details of development and reproduction are not as well known as in the two later described species.

4. U. PROSTRATA Gardner, 1909, p. 373, Pl. XIV, figs. 1 and 2. Frond epiphytic, the disk of 2-3 layers of cells in the middle, of one layer near the margin, composed of radiating filaments, free at the margin, all firmly adherent to the host; cells each with a band-shaped chromatophore and one pyrenoid, 6-7 μ diam., about 1 diam. long near the center of the disk, increasing to 2½ diam. at the tips of the filaments; terminal cell blunt; color very dark green. On *Iridaea laminarioides* Bory, near San Francisco, Cal.

Forming obscure, circular cushions, 2-3 mm. diam. on the host, usually in the sterile part of the frond. The absence of hairs and tapering cells would seem to justify placing this species in *Ulvella*, but until something is known of the reproduction, there must be some uncertainty.

### 13. EPICLADIA Reinke, 1888, p. 241.

Frond microscopic, composed of filaments irregularly and densely branching, forming a coating on the surface of Bryozoa; branching in one plane, when well developed taking the form of a central membrane with filamentous margin; chromatophore a parietal layer with one pyrenoid. Reproduction by zoospores (gametes?) formed many in a cell, and escaping by a round hole in the wall. Only one species.

E. FLUSTRAE Reinke, 1889, p. 86; 1889a, p. 31, Pl. XXIV, figs. 5-9; Hazen, 1902, p. 225, Pl. XLII, fig. 2; P. B.-A., No. 160. Cells of the central plate irregularly polygonal, usually 7-12 μ diam., occasionally larger; of the free filaments short-cylindrical or irregular, 5-10 μ diam. Fig. 94. Greenland to N. Y. *Europe.*

On the northern New England coast this plant is common in spring and summer; at New York, Hazen reports it in May, but did not find it in summer and autumn. The Fuci that cover the rocks in the litoral zone are often overgrown with Flustra, Sertularia, etc.; these are usually of a whitish or yellowish color, but when covered by the *Epicladia*, they are dark green; the alga is thus easily detected.

### 14. PRINGSHEIMIA Reinke, 1888, p. 241.

Frond a monostromatic disk on the surface of other algae; marginal cells flat, interior cells wedge-shaped, with their length vertical to the basal plane; growth radial by division of the marginal cells; chromatophore a large disk with one pyrenoid. Asexual reproduction by biciliate zoospores with red-brown stigma, formed in the central cells, few in each cell, escaping through an opening in the wall. Sexual reproduction in distinct plants from the asexual, by biciliate gametes with reddish stigma, many in a cell. Only one species.

P. SCUTATA Reinke, 1889a, p. 33, Pl. XXV; P. B.-A., No. 1524. Disk 1-2 mm. diam.; cells varying much in size and shape; zoospores 15 μ diam., gametes 4 μ. On *Zostera* and various marine algae. Fig. 95. Greenland to Conn., Jamaica. *Europe.*

15. OCHLOCHAETE Thwaites in Harvey, 1846-1851, Pl. CCXXVI.

Filaments creeping, articulate, branching; all or nearly all the cells bearing each a very long, inarticulate seta, base not swollen.

O. FEROX Huber, 1892, p. 291, Pl. X; Rosenvinge, 1893, p. 931, fig. 42; P. B.-A., No. 1521. Filaments radiating from a center, more or less closely united to form a round or somewhat irregular disk; branching lateral, occasionally a branch rising above the rest and forming locally a tissue two cells thick; cells rounded or angular, up to 30 μ diam., chromatophore parietal with one pyrenoid; setae tubular, continuous with the cells; central cells enlarging to form sporangia, up to 30 μ diam., which develop each 20-30 4-ciliate zoospores, developing at once on coming to rest. Fig. 92. On *Cladophora*, *Chaetomorpha* and *Zostera*. Greenland, Mass. *Europe.*

*O. hystrix* Thwaites has been reported from Washington, Setchell and Gardner, 1903, p. 219, but there is some doubt as to the determination.

16. CHAETOPELTIS Berthold, 1878, p. 215.

Frond a more or less rounded disk, attached by the lower surface, gelatinous, composed of rounded cells, in more or less distinct radial series; cells uninucleate, with one pyrenoid, sometimes with long, gelatinous, hair-like prolongations from the cell wall; sexual reproduction by the union of biciliate gametes; asexual reproduction by 4-ciliate zoospores with red stigma. Fresh water.

There is some question as to the character of the chromatophore in this genus; Berthold, 1878, in the original diagnosis, stating that many small disk-shaped chromatophores were found in a cell; Huber, 1892, however, considers that the apparent separate disks are thickenings in a single parietal coating.

**C. americana** (Snow) nov. comb.; *Ulvella americana* Snow, 1899, p. 309, Pl. VII. Disk 1-3 mm. diam.; marginal cells 10-17×5-13 μ, squarish or horizontally elongate; central cells 10-13 μ diam., vertically elongate, ultimately in several layers; superficial cells sometimes producing evanescent gelatinous hairs; zoospores 4-ciliate, 10-15×8-13 μ, oval or nearly spherical, with numerous oil globules and large brick-red stigma; 4-8-16 produced in a cell, from which they escape together, surrounded by a common gelatinous envelope; germinating immediately after coming to rest, and producing a plant like the parent. Fig. 96. Mich.

The 4-ciliate zoospores with prominent red stigma, issuing from the mother cell in a common envelope, and the gelatinous hairs, all indicate *Chaetopeltis* rather than *Ulvella* as the proper genus for this plant. Moreover, *Ulvella* is a strictly marine genus as far as known, and has a structure more parenchymatous and less gelatinous.

From *C. orbicularis* Berthold and *C. minor* Möbius it would seem to be distinguished by the polystromatic disk. Some peculiar conditions noted by Miss Snow, such as germinating zoospores forming two or four zoospores of a secondary generation; also the assuming of a sort of Palmella-state, may be due to conditions of cultivation, but at any rate raise interesting questions.

### 17. CHAETOBOLUS Rosenvinge, 1893, p. 928.

Frond epiphytic, hemispherical or more rarely subglobose; cell division in all directions; in the hemispherical frond the cells of the basal margin radiately arranged; superficial cells, except those of the basal margin, and those covered by other algae, produced into long inarticulate setae, continuous with the cells producing them; reproduction by zoospores produced in the superficial cells? Marine.

Nearly allied to *Ochlochaete*, but normally polystromatic, while *Ochlochaete* is normally monostromatic. Only one species.

C. GIBBUS Rosenvinge, 1893, p. 928, fig. 41. Frond 100-150 μ diam., cells of irregular rounded form, up to 30 μ diam., with dense chromatophore; the free superficial cells with very long, slender setae, 4-5 μ diam. at the base, much more slender near the tip; the very narrow passage through the seta not partitioned off from the cell; zoospores have not been observed, but the appearance of the fronds sometimes indicates that they are probably formed in the superficial, bristle-bearing cells. On *Chaetomorpha melagonium*. Fig. 98. Greenland.

This plant usually grows in company with *Lithoderma* and other epiphytic algae, which often so cover it that the development of the setae is much obstructed.

18. ARTHROCHAETE Rosenvinge, 1898, p. 110.

Frond epiphytic or endophytic, incrusting, orbicular, pseudoparenchymatous, sending towards the interior of the host plant filaments which branch and spread in the medullary layer of the latter; superficial vegetative cells usually bearing each a long seta, separated from the cell by a partition, and itself with one or two partitions; sporangia formed from superficial cells, constituting a continuous layer, obovoid or cylindrical; the zoospores escaping by an opening at the top. Marine.

Only one species.

A. PENETRANS Rosenvinge, 1898, p. 111, fig. 24. Frond to 1½ mm. diam., 100 $\mu$ (8 cells) thick; sporangia 10-14 $\mu$ diam., 17-28 $\mu$ long. In old fronds of *Turnerella Pennyi*. Fig. 97. Greenland.

Distinguished from *Ulvella* by the presence of setae; from *Chaetobolus* by the articulate character of the setae, as well as by the filaments penetrating the host plant.

19. GONGROSIRA Kützing, 1843, p. 281.

Fronds of densely packed, articulate, simple or sparingly branched filaments, each attached by a disk-shaped expansion; cells about as long as broad or somewhat longer; chromatophore parietal, occupying nearly all the cell wall, with one pyrenoid; asexual reproduction by biciliate zoospores, also by akinetes.

A genus long considered doubtful, and from which most of the species have been removed; but probably to be maintained for the few remaining species.

G. DEBARYANA Rabenhorst, Algen, No. 223; Wille, 1887, p. 484, Pl. XVIII, figs. 106-114; Pl. XIX, figs. 115-135; P. B.-A., No. 1187. Filaments ascending, bright green, dichotomous, forming an irregular expanded stratum; cells of varying shape, 15-30, rarely 40 $\mu$ diam., 1-2 diam. long; membrane at first thin, becoming thick and lamellate; terminal cell swollen, up to 50 $\mu$ diam., developing into an orange colored akinete, or else developing into a sporangium producing 16 or more biciliate zoospores. On submerged wood, stones, and shells ; fresh water. Fig. 91. Cal. *Europe.*

20. CHLOROTYLIUM Kützing, 1843, p. 285.

Frond consisting of erect, branching, articulate filaments, forming bright green, firm, pulvinate coatings, sometimes incrusted with lime ; cells with band-shaped chromatophore, (with pyrenoid ?) ; asexual reproduction by biciliate zoospores, formed in large numbers in the cells ; also by 4-ciliate zoospores formed 4-16 each in small cells, resulting from division of the vegetative cells ; also by akinetes. Fresh water.

C. CATARACTARUM Kützing, 1843, p. 285, Pl. XVII ; Phyc. Univ., No. 290. At first in minute tufts, up to 4 mm. diam., soon confluent to a continuous layer ; filaments parallel, densely packed, 6-12 $\mu$ diam., of two kinds, one kind bright green, cells 1½-2 diam. long, the other lighter, nearly hyaline, cells 2-6 diam. long ; akinetes orange or vermilion, formed only from the shorter cells, 9-15 $\mu$ diam., globose or oblong-ellipsoid. Fig. 86. N. Y., Ky. *Europe.*

21. PILINIA Kützing, 1843, p. 273.

Basal layer of abundantly branched filaments, from which arise erect filaments, simple or branched, sometimes terminating in articulate hairs ; chromatophore covering the cell wall ; sporangia roundish, ovoid or clavate, terminal or lateral on erect filaments or sessile on the basal layer, the contents forming numerous biciliate zoospores, which escape through an opening at the summit ; development unknown.

KEY TO THE SPECIES OF PILINIA.

1. Filaments often ending in hairs. 7. *P. maritima.*
1. Hairs not present. 2.
   2. Endophytic. 3. *P. endophytica.*
   2. Not endophytic. 3.
3. Erect filaments short, densely packed. 4.
3. Erect filaments longer, yellowish. 5.
   4. Dark green ; filaments 8-12 $\mu$ diam.; on live shells. 1. *P. Lunatiae.*
   4. Yellowish green ; filaments 2-5 $\mu$ diam.; on pebbles. 2. *P. minor.*
5. Forming a rather firm, spongy coating on woodwork. 5. *P. rimosa.*
5. Forming a thin, soft coating. 6.

6. On shells, pebbles, etc.; sporangia on erect filaments. 4. *P. Reinschii.*

6. On woodwork; sporangia on basal layer, rarely lateral on erect filaments. 6. *P. Morsei.*

1. P. LUNATIAE Collins, 1908, p. 123, Pl. LXXVII, figs. 1-3; *Acroblaste Reinschii* P. B.-A., No. 162. Basal filaments soon becoming united into a subparenchymatous layer, cells of varying shape and size, roundish or angular, up to 15 $\mu$ diam.; erect filaments 8-12 $\mu$ diam., increasing in size upward, usually 5-6 cells in length, quite rarely up to 10 cells, densely branched and very compact, cells varying in size and shape in the same filament; terminal cell becoming the sporangium, differing but little from any other cell of the filament; color deep green. On live shells of *Lunatia heros* Adams. Mass.

Very common on *Lunatia* shells at Revere Beach, Mass., but not reported elsewhere. It forms a very deep rich green coating at the flat spiral of the shell, but on living shells only. The substance is very compact, the filamentous character being made out with difficulty. The spores are produced in the terminal cells of the upright filaments, slightly enlarged, but not otherwise changed. It is a plant of spring and early summer chiefly.

2. P. MINOR Hansgirg in Foslie, 1890, p. 146, Pl. II, figs. 17-22. Stratum thin-coriaceous or almost crustaceous, yellow-green, more or less extended; basal layer dense, individual filaments indistinguishable; erect filaments irregular, vertical or inclined, as small as 2 $\mu$ diam. at the base, increasing in size upward to as much as 7 $\mu$ at the summit; not much branched. Sporangia terminal, pyriform but rather irregular, $20\text{-}24 \times 10\text{-}12\ \mu$. On pebbles by the seashore. Mass.

*Northern Europe.*

The distinction between the basal and the erect filaments is less than in *P. Lunatiae*, but the sporangia are more clearly differentiated. In the only recorded American locality, it grew on pebbles between high and low tide marks, and when the tide was out was wet with cold water from a spring.

3. P. ENDOPHYTICA Collins, 1908c, p. 156. Frond of no definite form, consisting of usually short, simple or branched filaments, creeping among the filaments of the host; cells variable in form and size, cylindrical, clavate, subspherical or irregular, 7-22 $\mu$ diam., 1-5 diam. long; chromatophore light green, sometimes filling the cell, more commonly cup-shaped, at the upper end of the cell. Sporangia terminal, spherical or

ovoid, up to to 30 $\mu$ diam., containing numerous spores. In fronds of *Ralfsia Borneti* Kuckuck. Me. to Conn.

4. P. REINSCHII (Wille) Collins, 1908, p. 125; *Acroblaste sp.* Reinsch, 1879, p. 365, Pl. III.A. Basal layer of monosiphonous filaments, with rounded cells about as long as broad; vertical filaments about ½ mm. high, 5-8 $\mu$ diam., cells about twice as long as broad, cylindrical or slightly constricted at the nodes; sporangia ovoid, 16-20$\times$20-25 $\mu$; terminal or apparently lateral on the erect filaments. On shells and pebbles. Mass.

In this species the basal layer shows the filamentous character throughout, even when the filaments are laterally united; often they remain practically free. The color is a yellowish, somewhat olivaceous green; it has some resemblance to a small species of *Ectocarpus*. It is often mixed with *Microchaete grisea* Thuret, *Calothrix* species, and other small algae.

5. P. RIMOSA Kützing, 1843, p. 273; 1854, p. 20, Pl. XC.; P. B.-A., No. 971. Forming a dense, yellowish green stratum; basal layer of somewhat irregular cells, more or less torulose; erect filaments reaching a height of 2 mm., simple or branched, cylindrical or torulose, cells 7-10 $\mu$ diam., length of cell, 1-2 diam.; reproduction unknown. On woodwork near high water mark. Me. *Europe.*

Forms a very compact coating, that can be removed in pieces of considerable size; *Calothrix pulvinata* grew with it at the Maine locality, nearer low water mark; the stratum was continuous, *Calothrix* below, *Pilinia* above, the two mixed for a space in the middle.

6. P. MORSEI Collins, 1908, p. 126, Pl. LXXVII, figs. 4-6. Basal filaments irregularly contorted, more or less united; cells rounded, 8-15 $\mu$ diam., often divided longitudinally and forming a subparenchymatous membrane of two or more layers; erect filaments up to 2 mm. high, 7-11 $\mu$ diam., cells 1-2 diam. long, cylindrical or slightly moniliform; sporangia ovoid or pyriform, on the basal layer, sessile or on a few-celled pedicel. Fig. 90. On woodwork, N. J.

Showing more differentiation than the preceding species, assimilative and fertile growths being both distinct from the basal layer.

7. P. MARITIMA (Kjellm.) Rosenvinge, 1893, p. 933, fig. 43; *Chaetophora maritima* Kjellman, 1877, p. 51, Pl. IV, figs. 15 and 16. Frond subspherical, 1-3 mm. diam., basal layer not

strongly developed; erect filaments 6-10 $\mu$ diam.; cells about as long as broad, terminating in an inarticulate hair, or in an ovate-ellipsoid cell; sporangia terminal, clavate, $11\text{-}12 \times 16\text{-}21\ \mu$. Greenland.

This species forms a continuous layer, in company with *Calothrix*; the subspherical gelatinous thalli distinguish it from the other species of the genus. Under this should be included, according to Rosenvinge, *C. pellicula* Kjellman, 1883, p. 286, Pl. XXXI, figs. 4-7, which forms a thin slimy membrane on wood; Rosenvinge was unable to find the intercalary sporangia to which Kjellman refers, and which, if confirmed, would require the removal of the plant to another genus.

22. MICROTHAMNION Nägeli in Kützing, 1849, p. 352.

Frond very minute, consisting of a branching, monosiphonous filament, attached by a bulbous base; stem and branches of about the same size; first partition in branch some distance above base; terminal cell blunt; cells cylindrical, with thin wall; chromatophore a thin sheet, more or less completely covering the cell wall, without pyrenoid. Asexual reproduction by ovoid, biciliate zoospores without stigma, germinating immediately.

A genus of very minute plants, the frond not reaching the height of 1 mm.; in appearance resembling a small *Trentepohlia*, but differing in that the spores are produced in any cell of the filament, practically unchanged; not in more or less specialized sporangia.

KEY TO THE SPECIES OF MICROTHAMNION.

1. Ramification dense; main stem and branches indistinguishable.
   1. *M. Kützingianum*.
1. Ramification open; main stem distinguishable throughout.
   2. *M. strictissimum*.

1. M. KUETZINGIANUM Nägeli in Kützing, 1849, p. 352; Hazen, 1902, p. 191, Pl. XXVI, fig. 1; Pl. XXVII, figs. 2-4; P. B.-A., No. 568. Up to 200 $\mu$ tall, very densely and irregularly branched, main stem and branches indistinguishable; ramuli one- to several-celled, patent or curved; cells cylindrical or slightly clavate, 3-4 $\mu$ diam. in all parts of the frond, usually 2-4 diam. long, occasionally considerably longer; chromatophore bright green, usually covering the entire cell wall. Fig. 83. Mass. to N. Y. *Europe, New Zealand.*

Forming a thin coating on sticks, woodwork, etc., in streams; also in greenhouses.

2. M. STRICTISSIMUM Rabenhorst, Algen, No. 829; Hazen, 1902, p. 191, Pl. XXVI, figs. 2-5; P. B.-A., No. 1425. Up to 600 $\mu$ tall, erect, branching mostly alternate, the main stems distinguishable throughout; branches erect or ascending; cells cylindrical, 2.5-4 $\mu$ diam., about the same size all through the frond, 3-12 diam. long, or even more; chromatophore thin, pale green, often only partially covering the wall. Conn., N. Y. *Europe, So. America.*

In similar stations to the preceding species; distinguished by the greater size, longer articulations, and different ramification.

Var. MACROCYSTIS Schmidle, 1899, p. 169, Pl. VII, figs. 1-3; Hazen, 1902, p. 192, Pl. XXVII, fig. 1. Taller, branching more open; branches more slender than main stem, somewhat tapering; chromatophore pale and narrow; tips of branches colorless. Mass., N. Y. *Europe.*

Found growing on dead leaves in a rain water ditch.

23. CHAETOPHORA Schrank, 1813, p. 124.

Filaments arising from a palmelloid base, and united by a firm gelatinous substance into thalli of definite form; filaments repeatedly branched, of about the same diameter throughout, ramuli often in fascicles, frequently terminating in long setae. Chromatophore a parietal band with one or more pyrenoids. Asexual reproduction by biciliate zoospores, formed in the cells of the ramuli; akinetes from any cell.

The filaments are much like those of *Stigeoclonium*, but the branching has more of a dichotomous appearance; the whole is imbedded in a gelatinous mass of definite form, spherical, tubercular, or elongate and branching. The plants are attached to sticks, stones, etc., and are common in clear running water in spring; less common in quiet water.

KEY TO THE SPECIES OF CHAETOPHORA.

| | |
|---|---|
| 1. Thalli elongate, lobed and branching. | 4. *C. incrassata.* |
| 1. Thalli globose or tuberculose. | 2. |
| 2. Branching loose and spreading. | 1. *C. elegans.* |
| 2. Branching erect. | 3. |
| 3. Branches fascicled at the summit. | 2. *C. pisiformis.* |
| 3. Branches not fascicled at the summit. | 3. *C. attenuata.* |

1. C. ELEGANS (Roth) Agardh, 1812, p. 42; Wolle, 1887, p. 116, Pl. CIII, fig. 4-10; Hazen, 1902, p. 211, Pl. XXXVII; P. B.-A., No. 1026. Thalli globose or oftener tuberculose, up to 1 cm. diam, light green, rather soft; filaments radiating from the center, di-trichotomously branched and fasciculate above;

branches loose and spreading, except sometimes at the tips; ramuli short-pointed or setiferous; cells in main filaments 6-11, usually 8 μ diam., 3-10 diam. long; in ramuli 5-7 μ diam., 1-4 diam. long. Fig. 85. Mass. to N. J., Jamaica, Washington. *Europe.*

Ranging in size from hardly visible spheres to tuberculose and confluent forms, over 1 cm. diam.; mostly in spring, but occasionally at any time except when the brooks are frozen. In general character much like the two following species, but generally of lighter color, softer texture, and less regularly spherical shape.

2. C. PISIFORMIS (Roth) Agardh, 1812, p. 43; Harvey, 1858, p. 70; Wolle, 1887, p. 116, Pl. CIII, figs. 1-3, 12-15; Hazen, 1902, p. 212, Pl. XXXVIII, fig. 1. Thalli globose or tuberculose, 2-5 mm. diam., rather dark green, firm, seldom confluent; filaments radiating from the center, dichotomously, rarely trichotomously branched, branches erect or appressed, ramuli slender, acute, sometimes setiferous; cells in main filaments usually 6-7 μ diam., sometimes slightly more or less, 3-6 diam. long; in ramuli 4-6 μ diam., 1-3 diam. long. Me. to N. J., Washington. *Europe.*

The habit characters by which this differs from *C. elegans* are given under the latter species; microscopically, *C. pisiformis* has more slender filaments and more erect branching. The character of presence or absence of setae, formerly supposed to be of specific importance, is now known to be of no value, varying with age and circumstances. This species is especially a plant of running water.

3. C. ATTENUATA Hazen, 1902, p. 213, Pl. XXXIX; P. B.-A., No. 1520. Thalli globose or nearly so, not confluent, 2-5 mm. diam., bright green, dense and firm; filaments di-trichotomously branched, very erect and nearly parallel, not fasciculate; ramuli acute or setiferous; cells of main filaments 5-5.5 μ diam., 5-10 diam. long; of the ramuli about 4 μ, rather longer in proportion; branch-bearing cells often broadened and forked at the top; descending rhizoids abundant in the lower part of the frond. Mass., Conn., N. J.

In habit quite like *C. pisiformis*, but distinguished by more slender filaments, very regular branching, ramuli long and rather distant, rhizoids abundant. A plant of quiet water, and of summer rather than of spring.

4. C. INCRASSATA (Huds.) Hazen, 1902, p. 214, Pl.

XXXVIII, figs. 2 and 3; P. B.A., 1330; *C. endivaefolia* Harvey, 1858, p. 69; Wolle, 1887, p. 117, Pl. CIV; *C. cornu-damae* P. B.-A., No. 68. Thalli irregularly extended, lobed, laciniate, or branched, main filaments elongate, closely packed in skeins or strands, with alternate or secund branches bearing densely fascicled, usually setiferous ramuli; cells of main filaments 8-16 $\mu$ diam., 2-6 diam. long, cylindrical or inflated; ramuli often curved, often torulose, 6-11 $\mu$ diam., cells 1-2 diam. long. Generally distributed. *Europe, So. America.*

Thoroughly distinct from the three preceding globular species, but varying so much in form and ramification that it has received many specific and varietal names, but no clear lines can be drawn. Much of the variation appears to be due to the rapidity of the water in which it grows; between the forms with somewhat flattened and lobed thallus, 2-3 cm. long, and the slender, much branched, filamentous forms, several dm. long, every gradation can be found.

### 24. STIGEOCLONIUM Kützing, 1843, p. 253.

Frond mucilaginous, composed of a branching filament, without much distinction in character between main filaments and branches; terminal cells pointed or prolonged into a seta; chromatophore a parietal band, filling the smaller cells, zonate in the larger. Asexual reproduction by 4-ciliate zoospores with a red stigma; also by akinetes which produce 2-ciliate zoospores, by aplanospores, and also by a Palmella stage. Sexual reproduction by conjugation of 2-ciliate gametes with a red stigma.

A rather large genus of fresh water algae, very well limited but whose species show few sharp dividing lines.

KEY TO THE SPECIES OF STIGEOCLONIUM.

| | |
|---|---|
| 1. Opposite branching predominant. | 2. |
| 1. Alternate branching predominant. | 8. |
| 2. Filaments 10 $\mu$ diam. or less. | 6. *S. tenue.* |
| 2. Filaments 11-30 $\mu$ diam. | 3. |
| 3. Lower cells much inflated. | 5. *S. ventricosum.* |
| 3. Lower cells slightly or not at all inflated. | 4. |
| 4. Lower cells not over 2 diam. long. | 5. |
| 4. Lower cells 2-8 diam. long. | 6. |
| 5. Lower cells seldom as long as broad; ramuli tapering, thorn-like. | 4. *S. subuligerum.* |
| 5. Lower cells usually longer than broad; ramuli short-pointed. | 1. *S. lubricum.* |

| | |
|---|---|
| 6. Lower cells 2-5 diam. long. | 1. *S. lubricum* var. *varians.* |
| 6. Lower cells 3-8 diam. long. | 7. |
| 7. Ramuli pointed. | 2. *S. amoenum.* |
| 7. Ramuli setiferous. | 3. *S. flagelliferum.* |
| 8. Filaments short, tufted. | 9. |
| 8. Filaments more elongate. | 12. |
| 9. Of thermal waters. | 7. *S. thermale.* |
| 9. Of ordinary temperatures. | 10. |
| 10. Tips obtuse or short-pointed. | 8. *S. nanum.* |
| 10. Tips attenuate or setiferous. | 11. |
| 11. Ramuli scattered. | 13. |
| 11. Ramuli densely fasciculate. | 10. *S. glomeratum.* |
| 12. Filaments 5-7 $\mu$ diam. | 11. *S. attenuatum.* |
| 12. Filaments 8-11 $\mu$ diam. | 12. *S. stagnatile.* |
| 12. Filaments 12-18 $\mu$ diam. | 13. *S. subsecundum.* |
| 13. Filaments 7-9 $\mu$ diam. | 9. *S. aestivale.* |
| 13. Filaments 4-6 $\mu$ diam. | 14. *S. minus.* |

1. S. LUBRICUM (Dillw.) Kützing, 1845, p. 198; P. B.-A., No. 866; *S. tenue* var. *lubricum* Wolle, 1887, p. 111; *Myxonema lubricum* Hazen, 1902, p. 195, Pl. XXVIII, figs. 1 and 2. Tufts up to 30 cm. long, dark green, filaments much branched, the branching principally of the opposite type, but often several pairs, single branches or whorls arising from adjacent cells, these cells being subglobose and smaller than other cells in the same filament; ramuli abundant, opposite, scattered, or near the ends of the branches in more or less dense fascicles; smaller than the branches from which they arise, but only slightly if at all tapering; usually ending in a short point, but sometimes setiferous; lower cells somewhat swollen, 14-17 $\mu$ diam., $\frac{2}{3}$-2 diam. long, rarely more, with broad zonate chromatophore; ramuli 6-7 $\mu$ diam., cells about as long as broad. Fig. 84. Ontario, Mass. to N. J., Alaska. *Europe.*

The largest, and at least in the eastern states, the most common of our species; all the species with prevailingly opposite branching are grouped round this, resembling it in most characters, but with special developments on one or more lines. Like most of the species of *Stigeoclonium* it is a spring plant, inhabiting clear running water.

Var. **varians** (Hazen) nov. comb.; *Myxonema lubricum* var. *varians* Hazen, 1902, p. 198, Pl. XXVIII, figs. 3 and 4; Pl. XXXIII, figs. 4 and 5; P. B.-A., No. 1075. Tufts short, not exceeding 2 cm.; filaments seldom over 12 $\mu$ diam., cells 2-5 diam. long, with thin wall; ramuli longer-pointed. Mass. to New Jersey.

Appearing like a small and delicate state of *S. lubricum*, but considered by Hazen, who collected it in many localities, as a well defined variety.

2. S. AMOENUM Kützing, 1845, p. 198; Wolle, 1887, p. 113, Pl. XCVIII, fig. 4; P. B.-A., No. 1073; *Myxonema amoenum* Hazen, 1902, p. 199, Pl. XXIX. Light green, tufted, up to 10 cm. long; filaments much branched, after the type of *S. lubricum;* the ramuli tapering and pointed but rarely setiferous; cells in main branches cylindrical or slightly inflated, 11-16 $\mu$ diam., 3-8 diam. long, occasionally as much as 15 diam.; shorter above, in the upper branches about as long as broad; ramuli 6-8 $\mu$ diam. at base. Mass., R. I., Conn. *Europe.*

3. S. FLAGELLIFERUM Kützing, 1845, p. 198; 1853, Pl. X, fig. 1; Wolle, 1887, p. 112, Pl. XCVII, fig. 1; P. B.-A., No. 408; *Myxonema flagelliferum* Hazen, 1902, p. 199. Tufts up to 2 cm. long, bright green; branches mostly in pairs, 2-4 pairs on successive globose cells; ramuli flagelliform, tapering into long setae; lower cells 14-18 $\mu$ diam., 4-8 diam. long, cylindrical or slightly inflated; ramuli 9-10 $\mu$ diam. at base. Mass., Conn. *Europe.*

This and the preceding species have much in common, but *S. flagelliferum* is larger, with more elongate and tapering branches, and more abundant and better developed setae.

4. S. SUBULIGERUM Kützing, 1849, p. 354; *Myxonema subuligerum* Hazen, 1902, p. 200, Pl. XXX. Tufted, less than 1 cm. long; much branched after the type of *S. lubricum*, but branches spreading, ramuli divaricate, tapering from the rather thick base to an acute point, or occasionally into a short seta; cells cylindrical, about as long as broad, quite covered by the dense chromatophore; main branches 12-16 $\mu$ diam.; ramuli 6-9 $\mu$ diam. at base. N. Y., N. J., Cal. *Europe.*

Distinguished by the nearly uniformly opposite, divaricate branching, thorn-like ramuli, and dense chromatophores.

5. S. **ventricosum** (Hazen) nov. comb.; *Myxonema ventricosum* Hazen, 1902, p. 201, Pl. XXXI. Tufted, up to 1 cm. long; main branches as in *S. lubricum;* ramuli alternate or opposite, short, tapering to the rounded tip or into a short, rather obtuse seta; lower cells much inflated, 14-16 $\mu$ diam. at the ends, 27-30 $\mu$ at the middle, length 45-110 $\mu$; ramuli 6-8 $\mu$ diam. at the base; chromatophore a narrow zone in the large, inflated cells, occupying the greater part of the smaller cells. N. J.

The strongly inflated cells, with comparatively narrow zonate chromatophores, remind one of a *Draparnaldia*, and seem to characterize the species sufficiently.

6. S. TENUE (Ag.) Kützing, 1843, p. 253; Wolle, 1887, p. 110, Pl. XCVI, fig. 11; Wittr. and Nordst., Alg. Exsicc., No. 1429; *Myxonema tenue* Hazen, 1902, p. 202, Pl. XXXII. Tufts up to 1 cm. high, bright green; filaments slender, 7-10 $\mu$ diam. below, 5-6 $\mu$ in the ramuli; cells cylindrical or slightly swollen, 1-3 diam. long; in ramuli about as long as broad; main branches solitary or opposite, not many pairs together; ramuli numerous, scattered or opposite, short, erect, tapering to an acute point or a very slender seta. Mass., Conn., Vermont, N. Y., Cal. *Europe.*

A slender, loosely branched species, forming a transition from the opposite-branching *S. lubricum* group, to the less luxuriant, alternately branched species.

7. S. THERMALE A. Braun in Kützing, 1849, p. 353; 1853, Pl. II, fig. 4; Wolle, 1887, p. 111, Pl. XCVI, fig. 1; *Myxonema thermale* Hazen, 1902, p. 203. Filaments with somewhat creeping base, freely branching, ramuli distant, alternate or opposite, erect or patent, tapering to a point; cells 7.5-12 $\mu$ diam. below, 1-2 diam. long; in ramuli 3-5 diam. long.

A plant of warm springs and hot water escapes from mills, etc.

8. S. NANUM (Dillw.) Kützing, 1849, p. 354; Wolle, 1887, p. 112, Pl. XCVI, fig. 10; P. B.-A., No. 867; *Myxonema nanum* Hazen, 1902, p. 204. Two to three mm. high; branching alternate, ramuli tapering, obtuse or short-pointed; cells 6-8 $\mu$ diam., 1-2 diam. long. Neb., So. Dakota, Cal. *Europe.*

A not very strongly characterized species; perhaps a state of some other, but at present there is no evidence to connect it with any other form. As P. B.-A., No. 1375, there was distributed, as forma *subsimplex* Collins, a form from California, with filaments even shorter than in the type and hardly at all branched.

9. S. **aestivale** (Hazen) nov. comb.; *Myxonema aestivale* Hazen, 1902, p. 205, Pl. XXXIII, figs. 1-3; P. B.-A., No. 1074. Light green, forming dense tufts up to 1 cm. high; base palmelloid; branching alternate or dichotomous, erect; main filaments 7-9 $\mu$ diam., rarely more; cells 2-6 diam. long below, about as long as broad above, thin-walled, somewhat swollen; ramuli few, scattered or somewhat approximate near the summit, frequently attenuate into fine setae. Growing in dense tufts along the edges of troughs and fountains. Vermont, Mass., N. Y., Conn.

10. S. **glomeratum** (Hazen) nov. comb.; *Myxonema glomeratum* Hazen, 1902, p. 205, Pl. XXXIV. Tufts up to 1 cm. long, with palmelloid base; branches few below, alternate; above more frequent, usually alternate, rarely opposite, more or less densely fascicled near the summit, the ramuli tapering to an acute tip or a long seta; cells of main filaments cylindrical or slightly swollen, 11-14 μ diam., 2-7 diam. long, with broad, zonate chromatophore; cells of ramuli 6-8 μ diam., 1-2 diam. long, with dense chromatophore. In pools and fountains. Conn., N. Y.

11. S. **attenuatum** (Hazen) nov. comb.; *Myxonema attenuatum* Hazen, 1902, p. 206, Pl. XXXV; P. B.-A., No. 1328. Tufted or forming dark green lubricous skeins, up to nearly half a meter long; dichotomously divided near the base into many filaments, sparingly branched above; ramuli short, spinescent or flagelliform, solitary or 2 or 3 arising from the same point, less often opposite, tapering to an acute tip or a very slender seta; cells cylindrical, 5-7 μ diam., 2-5 diam. long; chromatophore thin and somewhat broken. Vermont, Mass., Conn.

Growing in watering troughs, where it has the habit of an *Ulothrix* rather than of a *Stigeoclonium*. In the two localities where it has been studied, it was found from Feb. to Nov.

12. S. **stagnatile** (Hazen) nov. comb.; *Myxonema stagnatile* Hazen, 1902, p. 207, Pl. XXXVI, figs. 1 and 2. P. B.-A., No. 1329. Forming floccose, floating masses; filaments elongate, bearing at long intervals solitary or opposite ramuli; short, thorn-like, often curved, tapering to a sharp point or a long seta; cells 8-11 μ diam., 1-3 diam. long, occasionally longer; ramuli 7-9 μ diam. at base. Mass., N. Y.

Always found floating, in company with filamentous algae of various kinds. It is of course probable that it is attached at some early stage, but this has not been observed.

13. S. SUBSECUNDUM Kützing, 1843, p. 253; Wolle, 1887, p. 112, Pl. XCIX, fig. 2?; *Myxonema subsecundum* Hazen, 1902, p. 207, Pl. XXXVI, fig. 3. Forming loose, pale green or yellowish tufts; filaments elongate, sparingly branched, 12-18, usually 16 μ diam.; cells 3-10 diam. long; branches never opposite; some branches elongate like the main stem, others shorter; cells 2-3 diam. long; all branches attenuate towards the apex; cells cylindrical, or dissepiments very slightly constricted. In ditches. N. J., So. Carolina, Jamaica. *Europe.*

A soft, pale green plant, especially characterized by the scanty ramification and the strongly tapering branches resembling *S. stagnatile*, but with larger cells, branches never opposite, forming dense tufts; never found in a floating state.

14. S. **minus** (Hansg.) nov. comb.; *S. longipilus* var. *minus* Hansgirg, 1886, p. 227; P. B.-A., No. 865. Forming dense tufts up to 5 mm. high; filaments radiating from a palmelloid base, 4-6 $\mu$ diam., cells 2-4 diam. long; filaments sparingly and irregularly branched, ending in a long hair; procumbent filaments arising near the base of the erect filaments, similar or slightly larger. Mass.

This plant was found growing on stems of plants in a clay-pit, Medford, Mass., June, 1900. It seems to be the *S. longipilus* var. *minus* of Hansgirg, but as pointed out by Hazen, *S. longipilus* is a plant of much larger dimensions. The small form seems to continue of the same size, not to pass into the typical *S. longipilus*.

### 25. DRAPARNALDIA Bory, 1808, p. 399.

Filaments united by a soft, gelatinous coating, not forming a thallus of definite form; main filaments attached by basal rhizoids, more or less branched, stout, bearing dense lateral fascicles of ramuli, much smaller than the main filaments, often setiferous. Chromatophore in the stem and large branches a parietal band, sometimes perforated, with numerous pyrenoids; in the cells of the ramuli, a layer covering the wall, with few pyrenoids. Asexual reproduction only from the cells of the ramuli, by 4-ciliate zoospores with red stigma, germinating immediately; also by akinetes and aplanospores; sexual reproduction by conjugation of 4-ciliate gametes, which, however, may germinate without copulation.

Common plants of running water, chiefly in spring; distinguished from *Stigeoclonium* and *Chaetophora* by the sharp contrast between the main stems and the ramuli; also from *Chaetophora* by the thin, amorphous character of the gelatinous coating.

KEY TO THE SPECIES OF DRAPARNALDIA.

1. Rachis of the fascicle of ramuli distinct throughout. 2.
1. Rachis of the fascicle of ramuli indistinct. 3.
  2. Fascicles erect, lanceolate, elongate. 1. *D. plumosa*.
  2. Fascicles spreading, broadly ovate, acuminate. 2. *D. acuta*.
3. Cells of main branches inflated, chromatophore narrow. 3. *D. glomerata*.
3. Cells of main branches cylindrical, chromatophore broad. 4. *D. platyzonata*.

1. D. PLUMOSA (Vauch.) Agardh, 1812, p. 42; Harvey, 1858, p. 72; Wolle, 1887, p. 109, Pl. XCIV; Hazen, 1902, p. 218, Pl. XL, figs. 1 and 2; P. B.-A., Nos. 21, 1224. Tufts up to 15 cm. long, branches spreading or ascending, solitary or opposite, fascicles of ramuli single, opposite, or whorled, usually erect, dense, lanceolate or ovate-acuminate in outline, with prolonged percurrent rachis; ramuli erect or ascending, subulate or setiferous; cells of main filaments and branches subcylindrical, 45-70 $\mu$ diam., 1-3 diam. long; ramuli 6-10 $\mu$ diam., 1-4 diam. long; chromatophore occupying $\frac{1}{4}$-$\frac{1}{3}$ the length of the large cells, proportionately broader in the smaller cells. Vermont to California. *Europe.*

A widely distributed and fairly common species; its most distinctive character is found in the dense, plumose fascicles of ramuli, acuminate in outline, with percurrent rachis.

2. D. ACUTA (Ag.) Kützing, 1845, p. 230; 1853, Pl. XIII, fig. 2; Hazen, 1902, p. 219; P. B.-A., No. 1072. Tufts up to 10 cm. long, branches spreading or ascending, solitary or opposite, fascicles of ramuli single, opposite, or whorled, somewhat dense, ascending or spreading, broadly ovate to lance-ovate and acuminate in outline, rachis usually distinct; ramuli ascending, often curved, subulate or setiferous; cells of larger branches somewhat inflated, or nearly cylindrical above, 50-90, rarely 110 $\mu$ diam., 1-2 diam. long; chromatophore not over half the the cell length in width; ramuli 6-10 $\mu$ diam. Mass. to N. J., Oregon. *Europe.*

Quite close to *D. plumosa*, and perhaps only a variety, but usually with larger stems, branching more spreading, fascicles of ramuli broader in outline.

3. D. GLOMERATA (Vauch.) Agardh, 1812, p. 41; Harvey, 1858, p. 72; Wolle, 1887, p. 108, Pl. XCII; Hazen, 1902, p. 220, Pl. XL, figs. 3 and 4; P. B.-A., No. 20. Tufts usually dense, up to 8 cm. long; filaments much branched, branches spreading or horizontal, solitary or opposite, moniliform, bearing very numerous scattered, opposite, or whorled fascicles of ramuli; fascicles mostly set at right angles to the stem and sessile, broadly orbicular to elliptical, rachis indistinct, ramuli spreading, crowded, subulate, often long-setiferous; cells of main branches much swollen, 50-90 or even 125 $\mu$ diam., $\frac{1}{2}$-2 diam. long; chromatophore here not over half as broad as the length of the cell, but proportionally broader in the smaller branches; ramuli 6-9 $\mu$ diam. Fig. 89. Maine to N. J., Minn., Cal. *Europe.*

A very common spring plant in brooks, etc., varying considerably in appearance, but easily recognized. At first it is deep green, but becomes quite pale later in the season, the empty cells remaining after the escape of the zoospores.

4. D. PLATYZONATA Hazen, 1902, p. 222, Pl. XLI. Loosely tufted, up to 7 cm. long; branches mostly opposite or whorled, horizontal; fascicles of ramuli at right angles to the stem, distinctly stalked, broadly orbicular in outline, ramuli somewhat symmetrically radiating from the summit of the rachis or its branches, subfusiform, acuminate or setiferous; cells of the larger branches cylindrical or slightly constricted at the nodes, 50-90 $\mu$ diam., 1 diam. long or less; chromatophore very wide, nearly or quite filling the cell, often reticular; ramuli 6-11 $\mu$ diam. Vermont, Mass., N. J.

Though reported from few localities only, this seems to be a quite distinct species, and it will probably be found in other places.

26. PLEUROCOCCUS Meneghini, 1842, p. 30.

Cells round, or angular by mutual pressure, dividing in all three directions, remaining attached in irregular masses of up to 32 cells or even more; chromatophore in form of small grains or united to a disk, with or without a pyrenoid; zoospores, aplanospores and zoogametes have been reported.

P. VULGARIS Meneghini, 1842, p. 38, Pl. V, fig. 1; Nägeli, 1848, p. 65, Pl. IV.E, fig. 2; P. B.-A., No. 760. Cells 4-6 $\mu$ diam., singly spherical but becoming angular when in contact, often 2 to many cells continuing attached. On wood, stone, and brick, in moist or shaded places. Fig. 106. From Greenland south. *Europe.*

Probably the nearest to omnipresent of all the algae, as it is found in practically every station, not submerged, where moisture is occasionally to be had. It forms the thin green coating found on stone walls, buildings and trees, especially on the north side; this preference for the north side of trees is usually so marked that one can determine the cardinal points of the compass, except in dense woods. It is found as far north as Greenland; whether it has a southern limit, going towards the equator, is not certain.

It forms a somewhat friable coating in dry weather, becoming gelatinous in rain; the cells may separate promptly after dividing, but oftener continue attached in larger or smaller numbers, the families of no definite form, sometimes seeming like the beginning of filaments; spores of various species of algae may be found germinating in company with *Pleurococcus*, and it is not always easy to distinguish them. Miss Julia W. Snow has proposed, 1899a, p. 189, a genus *Pseudo-Pleurococcus*, with two species, *P. botryoides* and *P. vulgaris*; but as pointed out by Chodat, 1902, the characters on which the new genus is founded belong also to *Pleurococcus vulgaris*.

There is little or no agreement among writers on algae as to what should be included in this genus other than *P. vulgaris*; taken in a broad sense it will include in whole or in part *Protococcus*, *Cystococcus*, *Chlorococcum*, *Chlorosphaera* and *Pseudopleurococcus*. So little is known as to American forms that might be placed in these genera, that only a mention need be given of such forms, with a reference that will indicate where to look for fuller particulars.

*P. Kützingii* G. S. West, 1905, p. 287, Pl. CCCCLXIV, figs. 9 and 10, from Barbados, is said by the author to be at once distinguishable from *P. vulgaris* by the small size of the cells, and by the yellow-green color. The diameter given, however, 3.8-5.7 $\mu$, differs little from what we have noted for *P. vulgaris*, and the shade of green in the latter varies under varying conditions of moisture and light.

*P. regularis* Artari, reported in plankton of Lake Erie, Snow, 1903, p. 381, Pl. II, fig. IX, is a problematical form, referred by Chodat to *Coelastrum*, by Oltmanns to *Chlorella* Beyerinck, itself a doubtful genus, claiming to include beside the present species, the species included in this work under *Palmellococcus* and *Zoochlorella*.

*P. aquaticus* Snow, 1903, p. 383, Pl. III, fig. X, appearing in laboratory cultures, must remain uncertain, as long as nothing is known of it in a natural condition.

*Chlorosphaera lacustris* Snow, 1903, p. 386, Pl. IV, fig. XIV, and *C. parvula* Snow, l.c., p. 386, Pl. IV, fig. XV, must also be considered questionable.

*Protococcus ovalis* Hansgirg in Foslie, 1890, p. 159, Pl. III, fig. 12. Another doubtful form; occurring in clefts of rocks near high water mark in Norway, and in a similar station on the coast of Maine. The cells are ovoid or ellipsoid, 8-10×9-12 μ, with thin wall and yellow-green contents, solitary or in a formless, not very mucilaginous layer.

27. UROCOCCUS Kützing, 1849, p. 206.

Cells spherical, solitary, originally green, changing to some shade of red or yellow, with large, granular, bell-shaped chromatophore and no pyrenoid; wall thick, lamellate, the older layers ultimately breaking at one side, but remaining attached at the other, forming a stipe-like prolongation, of about the same breadth as the cell.

A somewhat doubtful genus, which may ultimately be absorbed in *Gloeocystis*; it is represented in America by three forms, which have been described as species, but their distinctness is certainly open to question.

KEY TO THE SPECIES OF UROCOCCUS.

| | |
|---|---|
| 1. Marine. | 3. *U. Foslieanus.* |
| 1. Fresh water. | 2. |
| 2. Cells 6-15 μ diam. | 1. *U. Hookerianus.* |
| 2. Cells 25-50 μ diam. | 2. *U. insignis.* |

1. U. HOOKERIANUS (Hass.) Kützing, 1849, p. 206; Wolle, 1887, p. 201, Pl. CXXIII, fig. 13; *Haematococcus Hookerianus* Hassall, 1845, p. 325, Pl. LXXX, fig. 4. Cells globose or ellipsoid, 6-13 μ diam., blood-red when mature; stipe densely annulate, often forked. Pa. *Europe.*

2. U. INSIGNIS (Hass.) Kützing, 1849, p. 207; Wolle, 1887, p. 201, Pl. CXXIII, figs. 11 and 12; Phyk. Univ., No. 82; *Haematococcus insignis* Hassall, 1845, p. 324, Pl. LXXX, fig. 6. Cells globose, 23-53 μ diam., or including thick, lamellate wall, up to 70 μ diam., brownish, orange-yellow or brick-red when mature. Mass., Pa., Alaska, Vancouver. *Europe.*

In early stages like a *Gloeocystis*, with cells 3-5 μ diam.; increasing in size and number of cells, but continuing in gelatinous colonies until the cells are about 10 μ diam., when they become free and develop the annular wall and later the stipe. The species has been studied by Richter, 1886, and it would seem that the formation of the stipe does not occur until the period of active vegetation is past; for the greater part of its existence the species develops as a *Gloeocystis*.

3. U. FOSLIEANUS Hansgirg in Foslie, 1890, p. 156, Pl. III, figs. 4-6. Marine; cells 8-18 μ diam., green, becoming

dull orange; diam., including wall, 15-25 $\mu$; stipe rather short, distinctly annulate. Growing among various algae, mostly blue-green, in crusts near high water mark. Fig. 105. Me. *Europe.*

Much like *U. insignis*, and perhaps rather to be considered a small marine form of that species; in its early stages not unlike *Gloeocystis zostericola.*

Var. FERRUGINEUS Lagerheim, 1882, p. 75, Pl. III, figs. 31-33. Rusty yellow; larger than the type, up to 90 $\mu$ with wall. Greenland. *Northern Europe.*

28. DACTYLOTHECE Lagerheim, 1883, p. 64.

Cells cylindrical or oblong-ellipsoid, straight or slightly curved, with rounded ends, solitary or 2-4 united into a family, with broad, lamellate, persistent membrane; chromatophore parietal, occupying ⅔ of the cell wall, without pyrenoid; asexual reproduction by division in one direction only. Fresh water.

Like *Gloeocystis*, except for cell division being in one direction only, with consequent difference in the shape of the cells and families; reproduction by zoospores and akinetes has not been observed.

D. CONFLUENS (Kütz.) Hansgirg,* 1888, p. 140; *Gloeothece confluens* Nägeli, 1848, p. 58, Pl. I.G, fig. 1; Wolle, 1887, p. 325, Pl. CCX, fig. 6; Phyk. Univ., No. 483b. Cells 1.5-2.5 $\mu$ diam., 1½-3 diam. long, with ample membrane, in few-celled families, 10-15 $\mu$ diam. Forming a gelatinous, yellowish or flesh-colored layer on rocks. Fig. 118. Mass. *Europe.*

29. GLOEOCYSTIS Nägeli, 1848, p. 65.

Cells spherical, with bell-shaped chromatophore, covering most of the cell wall, and one pyrenoid; wall thick, more or less lamellate; asexual reproduction by repeated cell division, several generations of cells often remaining enclosed in the original mother cell wall, and the walls of the intermediate generations; also by biciliate zoospores, and by akinetes.

A genus very closely resembling in appearance, cell division, etc., the blue-green *Gloeocapsa;* differing in structure and color of contents and by the formation of zoospores; the latter have,

*The attribution of this name to Hansgirg may be open to question, as he does not actually use the binomial. His words are "Zu dieser Gattung dürfte *Gloeothece confluens* (Ktz.) Näg., (*Gloeocapsa confluens* Ktz.) in Rabh. Alg. Exsicc., No. 1231, und wahrscheinlich auch noch *Gloeothece distans* Stiz. gehören." There seems here to be involved, in addition to the usual rules of nomenclature, the question as to the exact signification of a German auxiliary verb.

however, been observed in only a few species; other species have been passed back and forth between the two genera; the chief difficulty is not in knowing whether an alga under examination belongs to the Chlorophyceae or to the Cyanophyceae, but in knowing whether the long lost original of a scanty specific description belonged to one or the other. Fresh water and marine.

It is quite probable that supposed species of this genus are merely stages of other algae, like the "Palmella-stage"; others seem to be permanent, and not connected with any other organism. The only sure test would be prolonged cultures under varying conditions; but observations for a series of years of *G. vesiculosa* and *G. rupestris*, in a state of nature, have shown great uniformity. Other species are here included which seem fairly well marked.

KEY TO THE SPECIES OF GLOEOCYSTIS.

| | |
|---|---|
| 1. Marine. | 6. |
| 1. Fresh water. | 2. |
| 2. Cells not over 6 μ diam. | 3. |
| 2. Cells 6-12 μ diam. | 4. |
| 3. Forming a soft coating, or scattered among other algae. | 5. |
| 3. Forming a firm, cartilaginous layer. | 4. *G. Paroliniana.* |
| 4. Cells 6-8 μ diam., bright green. | 1. *G. vesiculosa.* |
| 4. Cells 9-12 μ diam., more or less brownish. | 3. *G. gigas.* |
| 5. On pottery and glass in greenhouses. | 6. *G. fenestralis.* |
| 5. On wet rocks. | 2. *G. rupestris.* |
| 6. Cells averaging over 15 μ diam. | 5. *G. zostericola.* |
| 6. Cells averaging 4-6 μ diam. | 7. *G. scopulorum.* |

1. G. VESCICULOSA Nägeli, 1848, p. 66, Pl. IV.F.; Wolle, 1887, p. 196, Pl. CLXVI, figs. 9-15; P. B.-A., No. 609. Cells bright green, globose or flattened, solitary or 2-8 forming a family 16-35 μ diam.; membrane soft, hyaline, lamellate; among other algae, on wet rocks, etc., rarely forming a distinct stratum. Me., Mass. *Europe.*

2. G. RUPESTRIS (Lyngb.) Rabenhorst, 1863, p. 128; Wolle, 1887, p. 196, Pl. CLXVI, figs. 19-21; P. B.-A., No. 608. Cells green, globose, 3-5 μ diam., solitary or 4-12 forming a family 12-60 μ diam.; membrane soft, hyaline, lamellate, quite wide. Greenland, Mass. *Europe.*

In the same stations as *G. vesiculosa*, and often in company with the latter; distinguished by the smaller cells, more in a family, with relatively wider membrane.

3. G. GIGAS (Kütz.) Lagerheim, 1883, p. 63; Phyk. Univ. No. 638; *G. ampla* Wolle, 1887, p. 196, Pl. CLVI, figs. 2-8. Cells globose or oblong-ellipsoid, 9-12 μ diam., solitary or 2-8 forming a family 45-95 μ diam.; membrane thick, distinctly lamellate; contents green, but containing brownish oil globules; forming gelatinous, roundish, dull green or brownish masses on submerged objects. Me., Mass., W. I. *Europe.*

When the brownish oil drops are abundant, it is called var. *rufescens*, but the distinction is not worth a name.

4. G. PAROLINIANA (Menegh.) Nägeli, 1848, p. 65; Phyk. Univ., Nos. 23, 597; *Microcystis Paroliniana* Meneghini, 1842, p. 78, Pl. X, fig. 2. Cells 3-6 μ diam., globose, 2-8 forming a family not over 24 μ diam.; membrane hyaline, lamellate; contents yellowish; forming a firm incrusting stratum on wet rocks, etc., about 2 mm. thick. Mass., N. H., Canada. *Europe.*

Distinguished by the yellowish color, and the small families united into a firm stratum.

5. G. **zostericola** (Farlow) nov. comb.; *Gloeocapsa zostericola* Farlow, 1882, p. 68; *Gloeocystis chrysophthalma* P. B.-A., No. 219. Marine; cells spherical or by mutual pressure flattened-hemispherical, 19-26×9-11 μ, 2-4 united to form a family 40-100 μ diam.; membrane ample, lamellate; contents brownish; forming brownish masses on *Zostera marina*. Wood's Hole, Mass.; has not been observed elsewhere.

6. G. FENESTRALIS (Kütz.) A. Braun in Wittr. and Nordst., Alg. Exsicc., No. 444; P. B.-A., No. 566; *Gloeocapsa fenestralis* Kützing, 1849a, Pl. XV, fig. 5. Cells globose or oblong, 2-4.5 μ diam., with membrane 7-15 μ, solitary or 2-18 forming a family, 15-50 μ diam.; membrane hyaline, thick, lamellate, chromatophore bright green; forming a thin, soft, pale or yellowish stratum in greenhouses, etc. Mass., R. I. *Europe.*

7. G. SCOPULORUM Hansgirg in Foslie, 1890, p. 155; Collins, 1908a, p. 155. Cells 4-6 μ diam., united in colonies of 2-8 cells, envelop distinctly stratified; forming greenish-yellow gelatinous masses in company with other minute algae, near high water mark. Me. *Europe.*

A doubtful species; possibly a state of *Ulothrix* or *Urospora*.

30. GLOIOCOCCUS A. Braun, 1851, p. 170.

Cells globose, enclosed in greater or less number in an ample globular transparent gelatinous mass; with bell-shaped chromatophore and one pyrenoid. Asexual reproduction by division of a cell into four daughter cells, by the formation of aplanospores, and by the formation of biciliate zoospores, of two sizes.

G. MUCOSUS A. Braun, 1851, p. 170; P. B.-A., No. 1516; *Sphaerocystis Schroeteri* Chodat, 1897, p. 292, Pl. IX. Cells 6-10 μ diam., colonies 50-1200 μ, perfectly spherical and transparent. Common in plankton of quiet fresh water. Fig. 122. Me., Mass. *Europe.*

31. GLOEOTAENIUM Hansgirg, 1890, p. 10.

Cells globose, subellipsoid, or flattened, united in flattened, rounded families of 2 or 4 cells, with wide and distinctly lamellate gelatinous walls; chromatophore a somewhat curved disk, with no pyrenoid; each family encircled by one or more dark-colored, opaque rings.

Little is known in regard to the reproduction in this genus, but it is probably similar to that in *Gloeocystis*; the only noticeable difference between the two genera is found in the peculiar dark bands, whose nature is imperfectly known. Only one species.

G. LOITLESBERGERIANUM Hansgirg, 1890, p. 10; G. S. West, 1905, p. 288, Pl. CCCCLXIV, figs. 22 and 23. Cells 15-24×18-21 μ, united in 2 or 4-celled families; in 2-celled families, including teguments, 42-70×28-40 μ, 24-30 μ thick; in 4-celled families 60-80×40-60 μ, 30-40 μ thick; 2-celled family encircled by one opaque band, 10-30 μ wide; 4-celled family by two such bands, intersecting on the flat side, and appearing cruciform seen from that side. In still water among other algae. Fig. 109. Trinidad. *Europe.*

32. PALMODICTYON Kützing, 1845, p. 155.

Cells similar to those of *Gloeocystis*; families of 1-3 generations included in a wide, gelatinous wall; combined into a gelatinous, subcylindrical thallus, more or less branching and anastomosing; reproduction by akinetes.

Differs from *Gloeocystis* by the combination of the families into a gelatinous thallus of definite shape.

P. VIRIDE Kützing, 1845, p. 155; West, 1904, p. 247, fig. 115. Cells 5-9 μ diam., families up to 50 μ diam.; thallus 1-several families wide, up to 2 mm. long, branching and anastomosing freely, the outer layer often more or less reddish. Fig. 107. Mass. *Europe.*

## Family 7. HERPOSTEIRACEAE.

Vegetative characters and asexual reproduction as in the Chaetophoraceae; sexual reproduction by antheridia and oogonia transformed from vegetative cells; oospore spherical, large, with four cilia, which disappear before fertilization by the smaller, pyriform, 4-ciliate spermatozoids. Only one genus.

HERPOSTEIRON Nägeli in Kützing, 1849, p. 424.

Frond microscopic, epiphytic, composed of simple or irregularly branched filaments; cells bearing on the upper surface long, hyaline, inarticulate setae, with bulbous base but no sheath; chromatophore parietal, with one or more pyrenoids. Asexual reproduction by 4-ciliate zoospores with red stigma, 1-4 in a cell; sexual reproduction by the union of a spermatozoid and an oospore, both 4-ciliate.

The forms included under *Herposteiron* and *Chaetosphaeridium* have all been included by authors under *Aphanochaete*, a generic name which apparently must be given up. Detailed reasons for this, as well as an account of the confusion in specific nomenclature, will be found under *Herposteiron* in Hazen, 1902.

KEY TO THE SPECIES OF HERPOSTEIRON.

1. Cells usually subglobose, 5-10 $\mu$ diam. 1. *H. confervicola.*
1. Cells usually subcylindrical, 4-6 $\mu$ diam. 2. *H. vermiculoides.*

1. H. CONFERVICOLA Nägeli in Kützing, 1849, p. 424; Hazen, 1902, p. 230, Pl. XLII, figs. 5-7; *Aphanochaete repens* Wolle, 1887, p. 119, Pl. CV, fig. 8; P. B.-A., No. 762. Creeping on various fresh water algae, filaments irregularly torulose; cells subglobose to nearly cylindrical; setae more or less frequent, about 3-4 $\mu$ diam. at base, very slender above, up to 200 $\mu$ long. Fig. 116. Greenland, Vt. to N. Y., Cal. *Europe.*

Probably not uncommon, but visible only on microscopic examination of the host. The setae are not as uniformly produced as in *Bolbocoleon* and *Chaetosphaeridium;* often only a small proportion of the cells are provided with them.

2. H. **vermiculoides** (Wolle) nov. comb.; *Aphanochaete vermiculoides* Wolle, 1887, p. 119, Pl. CV, figs. 9 and 10; P. B.-A., No. 161. Cells 4-6 $\mu$ diam., about as long as broad, more or less rounded, single or united in filaments, creeping on larger algae, or attached at two or more points, arched between; setae few or many, seldom over 50 $\mu$ long, with ellipsoidal base, one, rarely two or three from a cell, often absent. On *Zygnema*, *Hyalotheca*, etc. Conn., Pa.

Nothing being known of the reproduction, the position of this plant is doubtful. The shape of the filaments is singular, often reminding one of a canker worm or measuring worm in motion. Apparently the filament, attached in two places, grows so rapidly between these points that it forms an arch. Wolle's figure is unsatisfactory, giving no idea of the form of the cells or of the setae, and not showing the manner in which the filaments encircle the host.

### Family 8. COLEOCHAETACEAE.

Frond consisting of dichotomously branched, monosiphonous filaments; all prostrate on the substratum, or with erect branches, branches distinct or laterally united to form a disk, or a pulvinate mass; growth by division of terminal cells only; cells uninucleate, with a parietal chromatophore, covering nearly all the cell wall and one pyrenoid, often producing slender, sheathed setae; asexual reproduction by biciliate zoospores without stigma, produced one in a cell, escaping by an opening in the wall, and germinating directly; sexual reproduction by oogonia and antheridia, produced in some species on the same individual, in some species on separate individuals; antheridia formed by the division of vegetative cells, or by outgrowths from them, producing each one spherical, biciliate spermatozoid, released by the dissolving of the cell wall; oogonium formed of the terminal cell of a branch, which enlarges and at the same time sends out a tubular prolongation; after fertilization by the spermatozoid this is closed by a partition at its base, branches in some species growing out from the cell below the oogonium or the neighboring cells, and forming a more or less complete cellular coating to it, becoming red or red-brown. The oospore with its coating rests for a long period, then the spore divides and increases in size, breaking through and throwing off more or less completely the coating, and from each cell is produced a zoospore, which germinates and produces the ordinary plant. Only one genus.

COLEOCHAETE Brébisson, 1844, p. 29.

Characters of the Family.

This genus represents the highest type of fructification among the green algae, showing a considerable likeness to some of the lower forms of mosses, and possibly also an approach to some of the Florideae. The fronds of the various species form small, bright green disks or cushions on fresh water plants or other submerged objects.

KEY TO THE SPECIES OF COLEOCHAETE.

| | |
|---|---|
| 1. Forming gelatinous cushion-like masses. | 6. |
| 1. Forming monostromatic expansions. | 2. |
| 2. Filaments more or less distinctly radiate. | 3. |
| 2. Filaments spreading irregularly. | 5. |

3. Filaments laterally united. 4.
3. Filaments free. 1. *C. soluta.*
4. Disk somewhat irregular in outline; cells usually 25 μ wide or more. 4. *C. scutata.*
4. Disk regularly orbicular; cells seldom over 15 μ diam. 5. *C. orbicularis.*
5. Epiphytic. 2. *C. irregularis.*
5. Endophytic. 3. *C. Nitellarum.*
6. Forming uniformly rounded masses; filaments radiating from the center. 6. *C. pulvinata.*
6. Masses irregular; filaments with no common center. 7. *C. divergens.*

1. C. SOLUTA (Bréb.) Pringsheim, 1860, p. 6, Pl. I, figs. 2 and 3; Pl. IV, figs. 1 and 2; Wolle, 1887, p. 64, Pl. LXXII, figs. 1-7. Filaments branching, radiating from a common center, prostrate, not laterally united; vegetative cells 12-25 μ diam., 2-3 diam. long; oogonia at first lageniform, then globose, corticated, up to 200 μ diam., including cortex; oospore 100-150 μ diam.; antheridia flask-shaped, about 17 μ diam. Mass., N. J. *Europe.*

2. C. IRREGULARIS Pringsheim, 1860, p. 11, Pl. I, fig. 6; Pl. VI, figs. 3-9; Wolle, 1887, p. 65, Pl. LXXII, figs. 15-16. Filaments prostrate or decumbent, free or more or less united, quite irregular, not forming a disk; cells quadrangular or polygonal, up to 25 μ diam., 1-1½ diam. long; oogonia ovoid, either quite naked or somewhat corticated above, about 120×65 μ; antheridia? Pa., N. J. *Europe.*

The only species with regular outline to the frond, but filaments not laterally united.

3. C. NITELLARUM Jost, 1895, p. 434, Pl. XXXIV; *C. irregularis* P. B.-A., No. 974, not Pringsheim. Fronds endophytic in cell wall of *Nitella* or *Chara*; filaments simple or branched, more or less united to form a membranous expansion; cells very irregular in outline, much flattened; no erect branches; setae penetrating the wall of the host and projecting externally; oogonia spherical or flattened, more or less corticated above; antheridia small cells cut off from the vegetative cells, usually a number together. Mass., N. Y., Neb., Mexico. *Europe, So. America.*

Much resembling *C. irregularis* in general characters, except as modified by the peculiar habitat. Probably all reports of *C. irregularis* on *Chara* or *Nitella* refer to this species; it was distributed under the name of *C. irregularis* in P. B.-A., No. 974.

4. C. SCUTATA Brébisson, 1844, p. 29, Pl. II, figs. 1-7; Rabenhorst, Algen, No. 1126; Wolle, 1887, p. 64, Pl. LXXII, figs. 8-13. Dioecious; frond orbicular, subparenchymatous, monostromatic, composed of laterally united, branching filaments, radiating from a center; cells quadrangular, 25-45 $\mu$ diam., 1-3 diam. long; oogonia subglobose, naked below, corticated above, 140-160 $\times$ 120 $\mu$; antheridia produced 4 from the division of a vegetative cell. Mass., N. Y., N. J., Neb., Colo.
*Europe, Asia, So. America, New Zealand.*

Distinguished from all but *C. orbicularis* by the continuous, monostromatic frond.

5. C. ORBICULARIS Pringsheim, 1860, p. 11, Pl. I, fig. 5; Pl. III, figs. 6 and 7; Pl. VI, figs. 1 and 2; Wolle, 1887, p. 64, Pl. LXXII, fig. 14. Frond orbicular, parenchymatous, monostromatic, composed of laterally united, branching filaments; cells oblong, quadrangular or polygonal, 8-16 $\mu$ diam., about 2 diam. long; oogonia ovoid, 60-85 $\times$ 50-65 $\mu$, naked below, more or less corticated above; antheridia not known. Mass., N. J., Neb. *Europe, New Zealand, Hawaii.*

Closely resembling *C. scutata*, but more regular in outline, and with smaller cells; if antheridia should be found similar to those of *C. scutata*, it might be treated as a variety of the latter.

6. C. PULVINATA A. Braun in Kützing, 1849, p. 425; 1855, Pl. LXXXIX, fig. 3; Wolle, 1887, p. 64; P. B.-A., No. 75. Monoecious; frond pulvinate, gelatinous, composed of branching filaments, radiating from a common center; cells 20-40 $\mu$ diam., 1½-2 diam. long; oogonia at first lageniform, globose when mature, corticated, about 150 $\mu$ diam., including cortex; oospore 110 $\mu$ diam.; antheridia flask-shaped, sessile, near the oogonia, 17 $\mu$ diam., 2½ diam. long. Mass., Pa., Alaska.
*Europe.*

Easily distinguished from other species by the cushion-like, not disk-shaped frond, formed of regularly radiating filaments.

7. C. DIVERGENS Pringsheim, 1860, p. 5, Pl. I, fig. 1; Pl. II, fig. 2. Monoecious; frond pulvinate, gelatinous, composed of branching filaments, with no definite center; cells about 25 $\mu$ diam., 1-3 diam. long; oogonia including cortex up to 135 $\mu$ diam.; oospore to 95 $\mu$. Fig. 110. These dimensions are for the type, which has not yet been noted in America; we have

Var. MINOR Hansgirg, 1886, p. 39; P. B.-A., No. 1331. Cells 12-18 $\mu$ diam., 1-2½ diam. long; oogonia 60-80 $\mu$, oospore 50-70 $\mu$. On *Batrachospermum* and other algae. N. H. *Europe.*

The pulvinate thallus distinguishes this species from all others except *C. pulvinata*; the absence of a common center for the filaments from the latter.

## Family 9. TRENTEPOHLIACEAE.

Filaments branched, free or united into a membrane, cells uni- or multinucleate, chromatophore generally band-shape, sometimes breaking up into small disks, without pyrenoid; chlorophyll masked by haematochrome, coloring the cells yellowish-, brick-, or brown-red; asexual reproduction by biciliate zoospores, formed in sporangia borne on geniculate or hooked cells; the sporangia usually thrown off whole, the zoospores emitted only when the sporangia are moistened; sexual reproduction by biciliate gametes, formed in sporangia terminal on or intercalary in the vegetative filaments; these gametes often germinating without copulation.

Aerial algae, with special adaptations to this mode of life.

KEY TO THE GENERA OF TRENTEPOHLIACEAE.

1. Basal layer a well developed disk; erect filaments unbranched. 3. CEPHALEUROS.
1. Filaments of basal layer not forming a disk; erect filaments usually branched. 2.
   2. Filaments often bearing inarticulate setae. 2. NYLANDERA.
   2. Filaments not setiferous. 1. TRENTEPOHLIA.

### 1. TRENTEPOHLIA Martius, 1817, p. 351.

Basal filaments decumbent, producing erect filaments, simple or branched, parallel or irregular, cylindrical to moniliform, colored yellowish to red with haematochrome in the living plant, fading when dried; often with an agreeable violet odor; cells cylindrical to spherical, with band-shaped or broken chromatophore and no pyrenoid; asexual reproduction by biciliate zoospores, in sporangia borne on special hooked or curved cells; sexual reproduction by biciliate gametes in gametangia transformed from vegetative cells, lateral, terminal, or intercalary, spherical or ellipsoid.

A genus of terrestrial algae, forming matted layers on rocks, and on leaves and bark of trees. They range from arctic or high mountain regions to the tropics; most of the species are very variable, and many species have been described based on characters of little permanence; our species are here arranged after Hariot, 1889-90, quite a number of species before generally recognized being given as synonyms or varieties. A curious adaptation to the terrestrial habit of the genus is found in the fact that the ripe sporangia frequently are cast off from the frond entire, and emit the zoospores only when they fall into water, or are wet with dew or rain. The terrestrial habit makes the species of *Trentepohlia* very accessible to lichen-forming fungi, and in many cases it is rather an exception to find a plant not at all lichenized.

KEY TO THE SPECIES OF TRENTEPOHLIA.

| | |
|---|---|
| 1. Cells cylindrical. | 2. |
| 1. Cells roundish, ellipsoid or fusiform. | 7. |
| 2. Sporangia scattered or in series. | 3. |
| 2. Sporangia in a glomerule or raceme. | 6. |
| 3. Filaments subsimple, tapering, acute. | 4. *T. effusa.* |
| 3. Filaments branching, not tapering nor acute. | 4. |
| 4. Filaments 4-10 μ diam. | 3. *T. abietina.* |
| 4. Filaments 10-32 μ diam. | 5. |
| 5. Filaments usually 12-20 μ, sometimes a little more or less. | 1. *T. aurea.* |
| 5. Filaments 28-32 μ. | 2. *T. villosa.* |
| 6. Glomerule terminal. | 5. *T. arborum.* |
| 6. Raceme short, lateral. | 6. *T. Wainoi.* |
| 7. Filaments 6-12 μ. | 7. *T. lagenifera.* |
| 7. Filaments 12-44 μ. | 8. |
| 8. Growing on rocks, rarely on mosses. | 8. *T. Iolithus.* |
| 8. Growing on bark of trees. | 9. *T. odorata.* |
| 8. Growing on lichens. | 10. *T. rigidula.* |

1. T. AUREA (L.) Martius, 1817, p. 351; Hariot, 1889-90, p. 7; P. B.-A., Nos. 569, 1188, 1376; *Chroolepus aureum* Wolle, 1887, p. 121, Pl. CXV, figs. 1-21. Color golden to orange, yellowish when dry; basal filaments cylindrical or more or less torulose, erect filaments cylindrical or sometimes slightly constricted at the nodes, parallel or irregular, more or less branched, usually obtuse; forming dense tufts or extended strata; branches somewhat tapering; cells usually 12-20 μ diam., but with extreme forms 8-30 μ; membrane either smooth or roughened with minute scales; gametangia 20-38 μ diam., globose or ellipsoid, terminal or lateral, borne directly on the vegetative cells; sporangia similar, on the special curved cells.

An extremely variable species, inhabiting all parts of the world; characterized by the cylindrical, not mucronate filaments of moderate diameter, and by the solitary or seriate gametangia. In the typical form the membrane is usually smooth, and the gametangia scattered; *T. uncinata* (Gobi) Hariot is a synonym.

Var. POLYCARPA (Nees and Mont.) Hariot, 1889-90, p. 15; *T. polycarpa*, P. B.-A, No. 472; including *T. Tuckermanni* Mont. Membrane usually scabrous, gametangia larger, 24-45 μ, in long series; both this and the following variety pass into the type continually. Texas, Cal. *So. America.*

Var. SUBSIMPLEX (Caspary) De Toni, 1889, p. 237; P. B.-A., No. 1377. Erect filaments simple or with one or two short branches. Cal. *Europe.*

Var. **Pittieri** (De Wildeman) nov. comb.; *T. Pittieri* De Wildeman, 1894, p. 6. Filaments 18-25 μ diam., smooth, cells 2-5 diam. long; gametangia globose or ovoid, 40 μ diam., to 56 μ long, borne at the extremity of branches 9-12 μ diam., cells about 4 diam. long; tips of branches, and especially of the branches bearing gametangia, often coiling about other filaments of the frond; when this occurs with the fertile branches, there may be an appearance of a dense fascicle of gametangia on the filament. On leaves of various plants. Costa Rica.

The principal characters by which this could be distinguished from *T. aurea* are the rather larger and longer cells, the larger gametangia, and the cirrhous branches; but in view of the considerable range of forms included under the species, these characters do not seem sufficient to distinguish it. The gametangia are so designated from their form and position, the original description designating them only as "zoosporanges."

2. T. VILLOSA (Kütz.) Hariot, 1889-90, p. 18; Wittr. and Nordst., Alg. Exsicc., No. 1066. Erect filaments elongate, tufted, flexuous, branching, pellucid; cells 28-30 μ diam., 2-2½ diam. long; reproduction unknown.

The type does not occur with us, but we have var. *brachymeris* Hariot, cells 28-32 μ diam., 48-52 μ long. Dominica, Guadeloupe, Mexico. *Asia.*

The cells in the type are unusually long for this genus, but shorter in the variety; the diameter is quite uniform and larger than all but quite exceptional forms of *T. aurea.*

3. T. ABIETINA (Flotow) Hansgirg, 1886, p. 86; Wittr. and Nordst., Alg. Exsicc., No. 917; *Chroolepus abietinum* Kützing, 1854, Pl. XCI, fig. 2. Forming reddish, more or less confluent tufts, becoming ashy when dry; cells of basal layer more or less torulose, erect filaments cylindrical or in a few of the lower cells slightly torulose, 4-10 μ diam., about 3 diam. long; terminal cell sometimes considerably longer; gametangia on special cells,

but sometimes terminal; sporangia on special cells, spherical or slightly ovoid, 12-20 $\mu$ diam. Canada, N. H., Vt. *Europe.*

A northern species growing usually on coniferous trees, but it has been found on oaks in Europe. It is like the smallest forms of *T. aurea*, but the filaments are more delicate and flexuous; the gametangia are smaller, and are liable to be found anywhere on either erect or basal filaments.

4. T. EFFUSA (Krempelhüber) Hariot, 1889-90, p. 52, figs. 12 and 13; *T. setifera* P. B.-A., No. 117. Forming yellowish-brown patches, becoming whitish when dry; filaments of basal layer cylindrical or more or less torulose; erect filaments 120-300 $\mu$ high, 6-10 $\mu$ diam. at the base, tapering to a point, usually simple, but sometimes branched; cells 18-28 $\mu$ long; gametangia developed from cells of the basal layer or lowest cells of the erect filaments, spherical or ovoid, 16-20 $\times$ 22-30 $\mu$. Conn. *Asia, So. America.*

The tapering filaments seem to indicate a connection between this genus and the Chaetophoraceae; we have no species for which it is liable to be mistaken.

5. T. ARBORUM (Ag.) Hariot, 1889-90, p. 20, figs. 8 and 9; P. B.-A., No. 1522. Filaments tufted, elongate, branching, somewhat attenuate; branches usually patent and somewhat more slender than the main filament; cells 16-28 $\mu$ diam., 40-60 $\mu$ long; gametangia usually terminal; sporangia 2-7 together, the branch terminating in a swollen cell, on which are borne several nearly empty curved cells, each bearing a sporangium, spherical or ellipsoid, 18-24 $\times$ 24-32 $\mu$. Jamaica, Guadeloupe. *Asia, So. America, Australia.*

The vegetative filaments resemble *T. aurea*, but the arrangement of the sporangia is characteristic.

6. T. WAINOI Hariot, 1889-90, p. 19, figs. 6 and 7; P. B.-A., No. 1523. Tufts yellow-green, about ½ cm. high; filaments cylindrical, 16-28 $\mu$ diam., cells 2-4 diam. long, wall smooth and rather thin, branches more or less abundant, irregularly placed, terminal cell slightly attenuate. Gametangia (?) spherical, 28-40 $\mu$ diam., in more or less close series along the filaments; zoosporangia (?) about 12 $\mu$ diam., borne terminally on short, lateral cells, or on the terminal cells of branches arising from this cell. Fig. 117. California, Jamaica. *So. America.*

7. T. LAGENIFERA (Hildebrandt) Wille, 1887, p. 427; P. B.-A., No. 1470; *Chroolepus lageniferum* Rabenhorst, 1868, p. 373, fig. 104. Frond orange to crimson; both basal and erect

filaments of more or less torulose cells, branching, cells 6-12 $\mu$ diam., 2-3 diam. long; gametangia lageniform to subspherical, lateral or terminal, sessile or pedicelled, 8-12 $\mu$ diam., 20 $\mu$ long. W. I., Cal. *Europe, So. America.*

The peculiar "bottle-shaped" gametangia are the characteristic mark of this species.

8. T. IOLITHUS (L.) Wallroth, 1833, p. 151; Wittr. and Nordst., Alg. Exsicc., No. 921; Hariot, 1889-90, p. 26, fig. 14; *Chroolepus Iolithus* Wolle, 1887, p. 122, Pl. CXVI, figs. 9-12. Filaments forming a thinner or thicker stratum, color bright red, becoming olive green in drying; with a distinct and pleasant odor of violets; erect filaments straight, torulose, branching, branches curved, apparently dichotomous; cells swollen at the middle, with constricted nodes, 14-35 $\mu$ wide, 24-50 $\mu$ long; a few cells at the end of the filament or branch often cylindrical and more slender; membrane thick, with striations and other markings; gametangia lateral, intercalary or terminal; sporangia round, 20-48 $\mu$ diam., or ovoid, 36-40$\times$45-54 $\mu$. Me., Mass., N. H., Alaska, Cal. *Europe, Oceanica.*

A plant found in all parts of the world, but characteristic of high altitudes or latitudes; it usually grows on rocks, but occasionally spreads to the mosses also growing on the rocks.

9. T. ODORATA (Wiggers) Wittrock, 1880, p. 16; Hariot, 1889-90, p. 29, fig. 16; *Chroolepus odoratum* Wolle, 1887, p. 122, Pl. CXVI, fig. 6; *C. umbrinum* Wolle, 1887, p. 123, in part, Pl. CXVI, figs. 4 and 5. Filaments forming a more or less dense, brownish- to orange-red, sometimes pulverulent or tomentose stratum, without sharp distinction between horizontal and erect portions, flexuous, with short branches, more or less torulose, cells rounded, ovoid, ellipsoid or almost cylindrical, 10-30 $\mu$ diam., 1-1½ diam. long; membrane from thin to thick and lamellate; gametangia subspherical to ellipsoid, lateral, terminal, or intercalary; 20-30 $\mu$ diam.; sporangia of same size. Canada, Me., N. H., Mass., N. Y., N. J., Fla., Va., St. Vincent, Cal. *Europe, Asia.*

Var. UMBRINA (Kütz.) Hariot, 1889-90, p. 36, fig. 17; *T. umbrina* var. *quercina*, P. B.-A., No. 662. Filaments irregular and irregularly branched, cells rather loosely united.

A widely distributed and variable species, including a number of species of various authors. Following Hariot we can distinguish a typical form, with cylindrical filaments mostly straight and parallel, and cells firmly united, and the following varieties. All are found growing on bark of various trees, rarely on other objects.

Var. BETULINA (Rab.) Hariot, 1889-90, p. 50; P. B.-A., No. 1378. Cells ellipsoid, thick-walled, in fairly distinct filaments. Principally on birch trees. N. H. *Europe.*

10. T. RIGIDULA (Müll. Arg.) Hariot, 1889-90, p. 36, fig. 17; *Chroolepus umbrinum* Wolle, 1887, p. 123, in part, Pl. CXVI, figs. 1-3; *C. rigidulum* Wittr. and Nordst., Alg. Exsicc., No. 1422. Filaments reddish or yellowish, ascending, stiff, subdichotomously branched, torulose, branches elongate; cells fusiform-ellipsoid, swollen, with strongly constricted nodes, membrane thin, at first smooth and pellucid, soon covered with fine scales or fibrils; cells 16-24 μ diam. at middle, 12-15 μ at nodes, 24-36 μ long; gametangia spherical, 30 μ diam. Cuba. *Asia, New Zealand, So. America.*

A species of warm regions, always epiphytic on lichens, which may be attached either to rocks or to the bark of trees. It approaches some forms of *T. odorata*, but is more branched, with cells more moniliform, and with thinner membrane.*

2. NYLANDERA Hariot, 1890, p. 85.

Structure as in *Trentepohlia*, but all or many of the cells bearing inarticulate setae. Only one species.

N. TENTACULATA Hariot, 1889-90, p. 41, fig. 22. Tufts small, inconspicuous, brownish when dry; prostrate filaments short, little branched, 12-15 μ diam., cells spherical-ellipsoid, somewhat torulose, 1-1½ diam. long; each cell usually bearing on the upper surface one, rarely two or three, inarticulate setae, 4-5 μ wide, up to 90 μ long, with globose-capitate tip. Fig. 114. On bark, So. Carolina.

The setae clearly distinguish this species from *Trentepohlia*, and perhaps indicate an affinity with the Chaetophoraceae.

3. CEPHALEUROS Kunze in Fries, 1829, p. 327.

Frond of a basal layer of branching filaments, in one or more strata, with simple erect filaments, terminating either in a hair, or in a sporangium or group of sporangia, sexual or asexual.

Distinguished from *Trentepohlia* by the fuller development of the horizontal disk, the reduced development of the erect filaments and the presence of hairs.

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* *Chroolepus moniliforme* Nägeli in Kützing, 1849, p. 895, is a lichen, fide Hariot, 1889-90, p. 48. Wolle's plant, 1887, p. 123, Pl. CXV, figs. 30-33, appears to be the same.

C. MYCOIDEA Karsten, 1891, p. 64, Pl. IV, fig. 11; Pl. V, fig. 1; *Mycoidea parasitica* Cunningham, 1879, p. 312, Pls. XLII, XLIII, at least in part; P. B.-A., No. 763. Frond of several layers, attached to the substratum by rhizoids, with a thin general cuticle; hairs colored with haematochrome; very variable in shape and size of cells, amount of hairs, etc. On leaves of various tropical and subtropical trees. Fig. 123. Jamaica. *Tropics generally.*

Much confusion has prevailed as to this species, and the name here used may not be in strict accordance with the laws of nomenclature; but it seems safe to use it, as less likely to cause confusion, and it does not involve adding a new binominal to the list, already uncomfortably long.

*Phyllactidium tropicum* Möbius, 1888a, p. 225, Pl. VIII, figs. 1-15; *Hansgirgia flabelligera* De Toni, 1889, p. 263, is a doubtful form, concerning which there have been somewhat contradictory reports by different writers; it has been reported from Cuba and Porto Rico, and from most tropical countries. It is evidently nearly related to *Cephaleuros;* Karsten, 1891, p. 62, refers it, though with some doubts as to its validity, to the neighboring genus, *Phycopeltis.*

## Order V. SIPHONOCLADIALES.

Fronds multicellular, usually more or less branched; cells multi-, very rarely uninucleate, chromatophore net-shaped, or of numerous small disks.

KEY TO THE FAMILIES OF SIPHONOCLADIALES.

1. Filaments simple, unattached; sexual reproduction by oospores and antheridia. 5. SPHAEROPLEACEAE.
1. Filaments simple or branched; sexual reproduction isogamous. 2.
  2. Main axis distinct, of limited growth. 3.
  2. Main axis usually indistinct; all axes of unlimited growth. 4.
3. Axis bearing whorls of branches of limited growth and of form different from the axis. 4. DASYCLADACEAE.
3. Branches either similar to the axis, or forming a terminal tuft or membrane. 3. VALONIACEAE.
  4. Zoospores and gametes produced in little changed vegetative cells. 1. CLADOPHORACEAE.
  4. Zoospores produced in distinct, ultimately detached sporangia. Shell boring algae. 2. GOMONTIACEAE.

## Family 1. CLADOPHORACEAE.

Frond of simple or branching, monosiphonous filaments, free or more or less united laterally; cells multi-, rarely uninucleate, with chromatophore net-form, or broken into many small portions, with many pyrenoids; asexual reproduction by 4-ciliate zoospores (sometimes by biciliate?) and by akinetes; sexual reproduction by biciliate gametes; zoospores and gametes formed in little changed vegetative cells. Marine and fresh water.

KEY TO THE GENERA OF CLADOPHORACEAE.

1. Filaments simple. 2.
1. Filaments branched. 3.
2. Filaments firm, stiff. 12.
2. Filaments soft, flaccid. 12. HORMISCIA.
3. Branches free, not united to form a membrane or tissue. 4.
3. Branches united to form a membrane or tissue. 8.
4. Branches usually short, rhizoidal. 2. RHIZOCLONIUM.
4. Branches of successive orders, but of the same character. 5.
5. Partitions regularly at bases of branches. 6.
5. No partitions regularly at bases of branches. 5. CLADOPHOROPSIS.
6. Akinetes formed of swollen intercalary or terminal cells; zoospores unknown. 6. PITHOPHORA.
6. Akinetes unusual, little differentiated; propagation by zoospores. 7.
7. Specialized hooked or rhizoidal branches present; cell division largely intercalary. 4. SPONGOMORPHA.
7. No specialized hooked or rhizoidal branches; cell division chiefly terminal. 3. CLADOPHORA.
8. Filaments united in one plane. 9.
8. Filaments united in all directions, forming a solid or spongy frond. 11.
9. Frond continuous. 7. ANADYOMENE.
9. Frond perforate. 10.
10. Small secondary cells formed in the spaces between the filament cells, leaving rounded openings. 9. CYSTODICTYON.
10. No such secondary cells; openings angular. 8. MICRODICTYON.
11. Frond a spongy mass of network. 10. BOODLEA.
11. Frond spherical, solid or hollow. 11. DICTYOSPHAERIA.
12. Filaments regularly cylindrical or clavate; originally attached, sometimes later floating. 1. CHAETOMORPHA.
12. Filaments usually more or less irregular; not attached. 2. RHIZOCLONIUM.

1. CHAETOMORPHA Kützing, 1845, p. 203.

Frond of a single unbranched series of multinucleate cells, all but the usually longer basal cell capable of division; basal cell producing either a disk or more or less branched rhizoidal prolongations for the purpose of attachment; frond always attached, or loosening and continuing in a free state; membrane thick, firm, usually distinctly lamellate; asexual reproduction by 4-ciliate zoospores, produced in little changed cells; sexual reproduction by biciliate gametes. Marine, rarely fresh water.

KEY TO THE SPECIES OF CHAETOMORPHA.

1. Filaments 400-600 $\mu$ diam. 2.
1. Filaments less than 400 $\mu$ diam. 4.
  2. Filaments increasing noticeably in diameter from the base up. 1. *C. clavata*.
  2. Filaments of nearly uniform diameter except at the extreme base. 3.
3. Basal cell many times as long as any other; a southern species. 3. *C. antennina*.
3. Basal cell only slightly longer than the others; a northern species. 2. *C. melagonium*.
  4. Filaments over 40 $\mu$ diam. 5.
  4. Filaments not over 40 $\mu$ diam. 7.
5. Cells 3-8 diam. long. 6. *C. cannabina*.
5. Cells not over 2 diam. long. 6.
  6. Filaments 125-400, usually 200-250 $\mu$ diam., yellowish-green. 4. *C. aerea*.
  6. Filaments 125-175 $\mu$ diam., dark green; a southern species. 5. *C. brachygona*.
7. Filaments attached by a small disk; marine. 7. *C. californica*.
7. Filaments attached by coralloid, pluricellular branches; fresh water. 8. *C. chelonum*.

1. C. CLAVATA (Ag.) Kützing, 1847, p. 166; Vickers, 1908, p. 17, Pl. VII; P. B.-A., No. 371. Filaments erect, stiff, up to 60 cm. long, base 500-750 $\mu$ diam., gradually increasing to 1.5 mm. or more at the tip; lower articulations 3-4 diam. long, those of the upper part about as long as broad, more or less moniliform, color deep green.

Var. TORTA Farlow, P. B.-A., No. 571. Fronds loose and curled, cells less moniliform than in the type, and not increasing in diameter upwards so noticeably.

A tropical and subtropical species, found in W. I. and in southern California. In the latter region it occurs mostly as the variety, corresponding to the floating forms of other species of the genus.

2. C. MELAGONIUM (Web. and Mohr) Kützing, 1845, p. 204; Harvey, 1858, p. 85; Farlow, 1881, p. 46; P. B.-A., No. 412 (forma *typica*); No. 413 (forma *rupincola*); *Conferva melagonium*

Harvey, 1846-51, Pl. XCIX.A. Filaments erect, coarse and wiry, dark glaucous green, 400-500 $\mu$ diam.; cells 1-2 diam. long.

A common species from N. J. to Greenland, occurring also in Alaska; two forms are found; f. RUPINCOLA (Aresch.) Kjellman, growing attached and erect, usually quite straight, in lowest rock pools, and below; reaching the length of a meter in northern regions, seldom over a third of a meter on the New England coast; f. TYPICA Kjellman, unattached, lying loose in the sublitoral zone, forming crisped and entangled masses about the roots of *Laminaria*, etc.; the latter form has usually been known as *P. Picquotiana* Mont., but is now pretty generally recognized as a form of the present species. It seems unnatural to give the name of forma *typica* to what is apparently a later stage of the plant, but the exigencies of nomenclature require it. There is considerable variation in the size of the filaments, especially in f. *typica*, and the slender forms, sometimes as low as 300 $\mu$ diam., are not always easy to distinguish from *C. aerea*; but the greater rigidity and the dark glaucous green color are usually sufficient marks. It is a favorite host for epiphytes, and the number of species found growing on it in arctic regions is quite large.

3. C. ANTENNINA (Bory) Kützing, 1849, p. 379; Vickers, 1908, p. 17, Pl. VIII; Wittr. and Nordst., Alg. Exsicc., No. 1439; *C. pacifica* Kützing, 1849, p. 379. Filaments dark green, 450-550 $\mu$ diam., erect, somewhat flexuous, stiff below, less so above; articulations 2-4 diam. long; the lowest cell 8-50 diam. long. W. I., Atlantic and Pacific coasts of Mexico. *Africa*.

In habit resembling *C. melagonium* f. *rupincola*; distinguished by the longer cells and the very long basal cell, which tapers much at the base. *C. melagonium* is an Arctic species, very luxuriant in Greenland, only much reduced forms being found south of Cape Cod; *C. antennina* does not appear to go farther north than Cuba on the west and Morocco on the east side of the Atlantic.

4. C. AEREA (Dillw.) Kützing, 1849, p. 379; Harvey, 1858, p. 86; Farlow, 1881, p. 46; P. B.-A., Nos. 76, 1526; *Conferva brachyarthra* Kützing, 1845, p. 203; *Conferva aerea* Harvey, 1846-51, Pl. XCIX.B. Filaments erect, yellowish-green, 125-400 $\mu$ diam., cells about as long as broad, base of filament usually

more slender than the upper part; when producing spores the fertile cells are much inflated and nearly globular. Fig. 115.

In upper litoral, especially in rock pools, from Me. to W. I. and in Cal. In habit like *C. melagonium*, but of somewhat smaller diameter, lighter color and softer texture; not firm enough to stand erect when taken from the water.

Forma **Linum** (Fl. Dan.) nov. comb.; *Conferva Linum* Harvey, 1846-51, Pl. CL.A; *Chaetomorpha Linum* Farlow, 1881, p. 47; P. B.-A., No. 22; *C. sutoria* Harvey, 1858, p. 87; *C. Olneyi* Harvey, 1858, p. 86, Pl. XLVI.D; *C. longiarticulata* Harvey, 1858, p. 86, Pl. XLVI.E. Filaments unattached, prostrate, light green, rather stiff, diam. 200-250 $\mu$, cells about as long as broad. Apparently bearing the same relation to typical *C. aerea* as the loose form of *C. melagonium* does to the attached form. It occurs in great masses of curled and crisped filaments in warm shallow bays, at least from N. S. to W. I.

5. C. BRACHYGONA Harvey, 1858, p. 87, Pl. XLVI.A; P. B.-A., No. 622. Filaments free, rigid, curved and twisted, forming strata of some extent on rocks or among other algae; cells 125-175 $\mu$ diam., quite uniformly as long as broad, except just after dividing. Fla., W. I., Mexico.

Usually found in entangled masses among other algae, in the same way as the more northern *Rhizoclonium tortuosum*, which has, however, more slender filaments and proportionally longer cells. *Rhizoclonium capillare* Vickers, 1905, p. 55, appears to belong here.

6. C. CANNABINA (Aresch.) Kjellman, 1889, p. 55; P. B.-A., No. 916. Filaments unattached, soft and rather delicate, 75-100 $\mu$ diam., narrow and wide together in the same tuft, or even a single filament tapering from largest to smallest measurement; cells pretty uniformly 500 to 600 $\mu$ long, being from 3-8 diam.; color light green. Me., Alaska, Washington.

*Northern Europe.*

Usually occurring in tangled masses, distinguished from the other species of northern range by the combination of softer texture, longer cells, and light color.

7. C. CALIFORNICA Collins, P. B.-A., No. 664; 1906, p. 106. Filaments attached by a small disk, about 20 cm. long, straight or flexuous, of uniform diameter throughout, not contracted at the nodes, 20-40 $\mu$ diam., cells 1-2 times as long as the diam., rarely 3-4 times. In shallow sandy pools near high water mark, Southern California.

The most slender erect marine species known, not likely to be mistaken for any other.

8. C. CHELONUM Collins, 1907, p. 198. Filaments erect, straight, 12-20 $\mu$ diam. at the base, increasing to 35 $\mu$ diam. above; lower cell up to 50 diam. long, following cells 5-10 diam., upper cells 2-3 diam.; wall thick; attached by coralloid, pluricellular branches; fertile upper cells moniliform to globular, up to 50 $\mu$ diam., 1-4 diam. long. Mich.

The only fresh water *Chaetomorpha* known in America, and distinguished from all other species, fresh water or marine, by the pluricellular branches issuing from the base of the filament, which may form a dense, inextricable mass on the substratum, which in the original and so far only known station was the backs of living turtles.

Doubtful species.

*C. saccata* Kützing, 1849, p. 380.

*C. intestinalis* Kützing, 1849, p. 380.

*C. media* Kützing, 1849, p. 380.

*C. tenuissima* Crouan in Mazé and Schramm, 1870-77, p. 51.

2. RHIZOCLONIUM Kützing, 1843, p. 261.

Filaments usually prostrate, of a single series of multinucleate cells, with net-shaped chromatophore and several pyrenoids, unbranched or in some species with a few irregular branches similar to the axis, and with more or less numerous rhizoidal branches, mostly unicellular, but sometimes of several cells. Asexual reproduction by biciliate zoospores with stigma, escaping through an opening in the cell wall; also by akinetes; but in only a few species has either form of fructification been found.

Common plants of fresh and salt water, often forming extensive mats in shallow water or on ground in the litoral zone; the filaments resembling those of *Chaetomorpha*, but less uniformly cylindrical, there being almost always more or less irregularity in the form of the cells. The short rhizoidal branches, when present, clearly characterize the genus, but they are not always developed, and when they are absent, the resemblance to *Chaetomorpha* is deceptive. In the few species where there are branches other than rhizoidal, they are formed quite differently from those of *Cladophora*, the branch pushing the original filament out of place, itself continuing in the original direction.

KEY TO THE SPECIES OF RHIZOCLONIUM.

| | | |
|---|---|---|
| 1. Marine. | | 2. |
| 1. Fresh water. | | 6. |
| 2. Branches at least in part similar to the axis. | | 3. |
| 2. Branches when present short and rhizoidal. | | 4. |
| 3. Forming erect tufts, branching only at the base. | 1. | *R. erectum.* |
| 3. Branching not limited to base of tuft. | 2. | *R. pachydermum.* |
| 4. Filaments 10-14 μ diam.; branching not observed. | | 5. |
| 4. Filaments 15-30 μ diam.; branches few or many. | 3. | *R. riparium.* |
| 4. Filaments 40-70 μ diam. | 4. | *R. tortuosum.* |
| 5. Cells 1-2 diam. long. | 5. | *R. Kochianum.* |
| 5. Cells 3-7 diam. long. | 6. | *R. Kerneri.* |
| 6. Branches frequent, pluricellular. | | 7. |
| 6. Branches wanting or unicellular. | | 8. |
| 7. Filaments 12-22 μ. | 9. | *R. fontanum.* |
| 7. Filaments 50-90 μ. | 10. | *R. Hookeri.* |
| 8. Cells rarely over 1½ diam. long. | 8. | *R. crispum.* |
| 8. Cells 2-8 diam. long. | | 9. |
| 9. Cell wall thin. | 7. | *R. hieroglyphicum.* |
| 9. Cell wall thick, 6-13 μ. | 11. | *R. crassipellitum*, var. *robustum.* |

1. R. ERECTUM Collins, 1901a, p. 291; P. B.-A., No. 975. Tufts erect, arising from prostrate filaments 70-100 μ diam., of irregular-shaped, very thick-walled cells, 1-2 diam. long, from which arise branches either simple or once or twice forking near the base, 20-50 μ diam., cells 3-6 diam. long; branches up to 30 cm. long, but so much and so regularly crisped that the tufts seldom exceed 10 cm. in height. In tide pools, lower litoral, exposed rocky shore. Me.

Resembling a *Cladophora* in general appearance, but with the branching limited to the base; intermediate between the two genera, but apparently nearer to *Rhizoclonium*.

2. R. PACHYDERMUM Kjellman, 1877, p. 55, figs. 26 and 28. Frond at first attached, main axis short, 85-100 μ diam., with more or less frequent branches, 50-75 μ diam., cells 1-2 diam. long; cell wall 10-15 μ thick, lamellate; main axis and branches of first and second order set with tapering branches of few cells, several times as long as their diam., with thin walls.

Var. TENUE Kjellman, 1883, p. 310. Principal branches usually 30-40 μ diam.; cell wall usually 5-6 μ thick; cauloid branches more numerous than in the type, rhizoidal branches fewer. Greenland, both type and variety. *Northern Europe.*

3. R. RIPARIUM (Roth) Harvey, 1846-51, Pl. CCXXXVIII;

1858, p. 92; Farlow, 1881, p. 49. Filaments usually pale green, forming expansions on ground or rocks in the litoral zone; cells usually 20-25 $\mu$ diam., rarely a little more or less, length one or two diameters.

A very common plant on both Atlantic and Pacific coasts, and probably in arctic and temperate regions the' world over; occurs also inland, near salt springs. Three varieties are to be recognized; there is no typical form distinct from these.

Var. IMPLEXUM (Dillw.) Rosenvinge, 1893, p. 915, fig. 34; P. B.-A., Nos. 266, 976. Forming a thin fleece on mud and sand in the litoral zone; branches few or none. Greenland to N. J., Alaska to Wash. *Europe.*

Var. POLYRHIZUM (Lyng.) Rosenvinge, 1893, p. 915, fig. 32; P. B.-A., No. 24. Sometimes found in the same localities as the preceding variety, but more commonly on perpendicular cliffs, where it hangs in skeins, attaching itself to the rock by numerous branches of one to few cells each. Greenland to Conn.; Cal. *Europe.*

Var. VALIDUM (Gobi) Foslie in Wittr. and Nordst., Alg. Exsicc., No. 624. Filaments stouter than in the type, 30-50 $\mu$ diam., branches frequently unicellular, often continuous with the filament cell. Greenland. *Northern Europe.*

*Rhizoclonium lanosum* Crouan in Mazé and Schramm, 1870-77, p. 53, No. 1179, and *Chaetomorpha submarina* Crouan, l.c., p. 52, No. 342, from authentic specimens, seem to belong under *R. riparium; Chaetomorpha lanosa* Crouan, l.c., p. 51, No. 251, is more slender, 10-15 $\mu$ diam., and seems to approach *R. Kochianum* Kützing.

4. R. TORTUOSUM Kützing, 1845, p. 206; Farlow, 1881, p. 49; P. B.-A., No. 23; *Chaetomorpha tortuosa* Harvey, 1858, p. 88, Pl. XLVI.B. Filaments dark green, 40-70 $\mu$ diam., cells 1-2 diam. long, forming curled and twisted masses in tide pools and similar localities. Common from Gaspé to N. Y.; reported from W. I.; Alaska to Washington. *Europe.*

Found mostly in summer on exposed shores, where the dark green crisped masses are very common in the lower pools; it is the *Chaetomorpha tortuosa* of Harvey, 1858, but hardly the species of that name in Hauck, 1885, p. 443. The type is without branches.

Forma POLYRHIZUM Holden, P. B.-A, No. 625. With abundant rhizoidal branches, of one to several short cells, similar to those of the main filaments, the terminal cell abruptly conical. Me., Conn.

5. R. KOCHIANUM Kützing, 1845, p. 206; Vickers, 1908, p. 18, Pl. XI; Le Jolis, Algues marines de Cherbourg, No. 236. Filaments simple, cells 12-14 $\mu$ diam., 1-2 diam. long. Forming masses of contorted filaments on other algae. Barbados. *Europe.*

6. R. KERNERI Stockmayer, 1890, p. 582; P. B.-A., No. 623; *R. Kochianum* Farlow, 1881, p. 49. Filaments pale yellowish-green, cells 10-14 $\mu$ diam., 3-7 diam. long; no branching. Me. to Conn.

This species and the preceding are of about the same diameter, differing chiefly in the length of the cells. *R. Kerneri* grows in masses, loose or mixed with other algae, in tide pools or below.

7. R. HIEROGLYPHICUM (Ag.) Kützing, 1845, p. 206; P. B.-A., Nos. 718, 1192; *R. lacustre* Kützing, 1849, p. 385; 1853, Pl. LXXII, fig. 4; *R. antillarum* Kützing, 1849, p. 384; *R. lacustre* forma *americanum* Wille, 1899, p. 149; P. B.-A., No. 624; *R. hieroglyphicum* var. *americanum* Wolle, 1887, p. 144, Pl. CXXI, figs. 31 and 32; Rabenhorst, Algen, No. 2496. Filaments not much curved or contorted, 10-25 $\mu$ diam., 2-5, rarely 1-7 diam. long, cells sometimes inflated at the middle, and of larger diam. there than given above; wall not over 2 $\mu$ thick; branches usually absent, when present, small, tubercular or rhizoidal, rarely partitioned off from the cell. Fig. 119. Mass., Conn., Pa., Ill., Mo., Minn., Fla., W. I., Cal. *Europe, Asia, So. America, New Zealand.*

A very common and variable species, including the greater part of the fresh water forms.

Var. MACROMERES Wittrock in Wittr. and Nordst., Alg. Exsicc., No. 630; P. B.-A., Nos. 119, 1191. Cells 20-30 $\mu$ diam., 5-12 diam. long. Mass., Conn., Cal. *Europe*

Var. **Hosfordii** (Wolle) nov. comb.; *R. Hosfordii* Wolle, 1887, p. 145, Pl. CXXII, figs. 13-16; P. B.-A., No. 719. Cells 36-40 $\mu$ diam., 3-6 diam. long, membrane thick; branches short, rhizoidal. Mass., N. Y.

Quite different from the ordinary form of *R. hieroglyphicum*, but connected by var. *macromeres*.

8. R. CRISPUM Kützing, 1845, p. 206; 1853, Pl. LXXI, fig. 1; Filaments 12-22 $\mu$ diam., usually much crisped, firm; cells 1-1½, rarely 2 diam. long; membrane thick, 3-4 $\mu$; branches infrequent, unicellular or continuous with the cell, acute. Me., N. J., Md. *Europe.*

Distinguished from *R. hieroglyphicum* by the thick membrane, firmer substance, and short cells.

9. R. FONTANUM Kützing, 1843, p. 261; 1853, Pl. LXXIV; *R. fontinale* Wolle, 1887, p. 144, Pl. CXXI, figs. 22-25. Filaments 12-22 $\mu$ diam., cells 2-4 diam. long, membrane thickish; branches usually abundant, mostly pluricellular. Me., Mass., Pa., Ill., Porto Rico. *Europe.*

10. R. HOOKERI Kützing, 1849, p. 383; 1853, Pl. LXVII, fig. 3; Hohenacker, Meeresalgen, No. 477. Filaments stiff, usually 70 $\mu$ diam., sometimes up to 90 $\mu$; cells 2-4 diam. long, wall thick, 4-10 $\mu$; branches sometimes few, sometimes many; often pluricellular, occasionally having branches of a second order. W. I. *So. America, Africa, Asia.*

A stout species, approaching *Cladophora* in its characters.

11. R. CRASSIPELLITUM var. ROBUSTUM G. S. West, 1905, p. 283. Filaments crisped, occasionally ventricosely inflated, curved and genuflexed; about 70 $\mu$ diam., cells 1½-2 diam. long, walls very thick and stratified, up to 13 $\mu$; apical cells somewhat attenuate and rounded, basal cell often inflated and producing rhizoids; no other branching. Forming mats on damp earth. W. I.

*R. crassipellitum* W. and G. S. West, 1897a, p. 35, with filaments 33-43 $\mu$ diam., wall 9-13 $\mu$ thick, is found in W. Africa.*

* W. and G. S. West, 1895, p. 265, Pl. XIV, figs. 17-24, describe *R. Berggrenianum* var. *dominicense;* filaments densely intricate, slender, cells 9-10 $\mu$ diam., 2-3 diam. long, wall usually thin, a large proportion of the cells with short, very obtuse, usually unicellular or continuous branches. In hot water stream in crater of volcano, Dominica. The typical *R. Berggrenianum* occurs in New Zealand, and is much like some forms of *R. hieroglyphicum*, but has akinetes 16-20 $\mu$ diam., 1·3 diam. long; it may be merely the akinete-producing form of *R. hieroglyphicum*. West's plant is probably an abnormal form, due to the hot water, etc.; as it has no akinetes, its connection with *R. Berggrenianum* is doubtful.

G. S. West, 1905, p. 283, reports from Barbados *R. hieroglyphicum* var. *Kochianum* (Kütz.) Stockmayer, giving the dimensions as diam. 23-29 $\mu$, cells 1½-2 diam. long. This would seem to agree better with the type, as Stockmayer gives 12-13 $\mu$ for the diameter of var. *Kochianum*.

*R. occidentale* Kützing, 1853, p. 22, Pl. LXIX, fig. 5, from Trinidad, seems from plate and description to be hardly distinguishable from *R. hieroglyphicum*. *R. hieroglyphicum* var. *atrobrunneum* Tilden, 1898, p. 90, Pl. VIII, figs. 14-17, from Yellowstone Park, hardly seems to have enough distinctness from the type to deserve a name. Four species in Wolle, 1887, must be considered doubtful; *R. stagnale*, *R. fluitans*, *R. Casparyi* and *R. majus*. From the plate CXXI, figs. 26-28, *R. fluitans* might be considered as a synonym of *R. crispum* Kütz.; but a specimen marked *R. fluitans* by Wolle proves to be *Microspora amoena* (Kütz.) Rab. If *R. stagnale* is the same as *R. stagnorum* Wolle n. sp., Rabenhorst Algen, No. 2577, it is probably a coarse short-celled form of *R. hieroglyphicum*.

3. CLADOPHORA Kützing, 1843, p. 262.

Frond composed of filaments of a single series of cells, the filaments branching, usually abundantly; branching lateral, but often coming to appear dichotomous in conseqence of the pushing aside of the original filament by the branch; growth chiefly by division of the apical cell, subsequent division of cells being rather exceptional; branches all of the same type; cells multinucleate, the chromatophore either covering the cell wall, or forming a network on it, or in the form of numerous small disks; pyrenoids several in a cell; asexual reproduction by 4-ciliate zoospores; sexual reproduction by biciliate gametes, uniting and germinating immediately; also sometimes germinating without copulation.

One of the largest genera of algae, the species abounding in fresh, brackish and salt water the world over; between 300 and 400 species have been described; many of them so insufficiently that they can hardly ever be recognized. There are few sharply marked characters for distinguishing the species, it being mostly a question of more or less in one respect or another. This is specially true of those inhabiting fresh water, of which an almost endless list of species, varieties and forms have been named, many duplicating each other, many founded only on temporary stages and abnormal conditions; a careful monographing of the genus would be a most valuable contribution to botany, but an exceedingly difficult task. In the meantime we must be contented with recording such forms as seem fairly well marked, leaving it for the future to determine what are autonomous species, what states and conditions.

Some species of *Cladophora* appear to be annual, some, perhaps the larger number, are perennial, the frond dying down almost to the base, which persists as a prostrate matted mass of cells, swollen and filled with reserve material; when new growth begins, the filaments issuing from the older cells, which cells may perhaps be considered as akinetes, are so distinct in character that if occurring separately they would pass for quite distinct species. Until recently there have been included under *Cladophora* the subgenera *Acrosiphonia* (or *Spongomorpha*) and *Aegagropila*; they are now more frequently considered as separate genera; while by some writers *Acrosiphonia* and *Spongo-*

*morpha* are separated, species with uninucleate cells being placed in the latter, those with multinucleate cells in the former; both being distinguished from *Cladophora* by specialized branches of a different type from the original normal filament. This distinction is not here maintained, all species with the specialized branches being included under *Spongomorpha*, the older name of the two. No such distinction is possible between *Cladophora* and *Aegagropila*, and there is quite a possibility that *Aegagropila* forms are often or always stages or conditions of true *Cladophora* species. *Aegagropila* is therefore not here maintained.

It has not seemed practicable to arrange the species in subgenera or sections; so many species are imperfectly known that any arrangement of this sort would be untrustworthy and misleading. For the determination of a specimen the key will serve as well, while leaving open the question as to which of the characters there used should be regarded as fundamental for classification. In this key the marine and fresh water species are given separately; an arbitrary division, but as the key is only for the purpose of determination, and does not attempt to indicate affinities, this plan seems justified. The marine species are first given, beginning with the more delicate erect species, then the larger and c arser, and ending with prostrate and matted forms; they are so varied that it is impossible to group them about any few centers; by bearing in mind that everything here is relative, not positive, it is hoped that the key will be of use to students. The fresh water species follow, falling naturally into two groups; one arranged about *C. fracta*, the other about *C. glomerata*; it may be that these two species should include the others, but for the present it is more convenient to keep them separate.

KEY TO THE MARINE SPECIES OF CLADOPHORA.

1. Plants with creeping, matted base. 2.
1. Plants erect. 6.
 2. Lower part of filaments 300-350 $\mu$ diam. 41. *C. intertexta*.
 2. Lower part of filaments less than 300 $\mu$ diam. 3.
3. Erect branches subsimple, much smaller than prostrate filaments. 38. *C. Howei*.
3. No sharp distinction between different kinds of filaments. 4.

4. Cells cylindrical throughout. 37. *C. Magdalenae.*
4. Some cells ovoid or pyriform. 5.
5. Cells 40-70, rarely 100 $\mu$ diam. 40. *C. amphibia.*
5. Cells 120-250 $\mu$ diam. 39. *C. trichotoma.*
6. Main filaments from 150 $\mu$ up. 7.
6. Main filaments seldom reaching 150 $\mu$. 10.
7. Lower cells 10 diam. long or more. 8.
7. Lower cells less than 10 diam. long. 11.
8. Di- or polychotomous branching normally from every cell. 34. *C. graminea.*
8. Several cells usually between successive branchings. 9.
9. Branching alternate or opposite, except near the base. 33. *C. catenifera.*
9. Branching generally dichotomous throughout. 35. *C. prolifera.*
10. Cells generally with a sharp constriction near the base. 12. *C. constricta.*
10. Cells without regular constrictions. 20.
11. Ramuli curved. 25. *C. microcladioides.*
11. Ramuli straight or nearly so. 12.
12. Ramuli clustered. 13.
12. Ramuli not clustered. 14.
13. Ramuli long, slender, cylindrical or nearly so. 26. *C. fascicularis.*
13. Ramuli short, stout, with constricted nodes. 28. *C. Hutchinsiae.*
14. Diameter nearly the same in all parts of the frond. 36. *C. fuliginosa.*
14. Terminal divisions markedly smaller than main stems. 15.
15. Filaments cylindrical. 22. *C. hirta.*
15. Nodes more or less constricted. 16.
16. Cells about the same length in proportion to the diameter in all parts of the frond. 32. *C. catenata.*
16. Upper cells proportionally shorter than the lower. 17.
17. Ultimate ramuli very short, often of a single cell; cells in ramuli ovoid, 1-2 diam. long. 18. *C. brachyclona.*
17. Ultimate ramuli not extremely short. 18.
18. Branching patent, except at the extreme base. 15. *C. crucigera.*
18. Branching generally erect. 19.
19. Ramuli not exceeding 60 $\mu$ diam. 30. *C. ovoidea.*
19. Ramuli 70-100 $\mu$ diam. 31. *C. utriculosa.*
20. Main filaments distinctly angled or flexuous. 21.
20. Main filaments straight or nearly so. 34.
21. Ramuli in clusters at tips. 22.
21. Ramuli not distinctly clustered. 23.

22. Fronds always attached. 46.

22. Fronds floating, except in earliest stages. 16. *C. expansa* f. *glomerata*.

23. Fronds floating, except in earliest stages. 24.

23. Fronds always attached. 28.

24. Ramuli in long pectinate series at ends of filaments. 26.

24. Ramuli scattered. 25.

25. Main filaments 100-150 $\mu$ diam. 16. *C. expansa*.

25. Main filaments 30-60 $\mu$ diam. 27.

26. Filaments 40-100 $\mu$ diam.; cells 4-8 diam. long. 21. *C. gracilis* v. *vadorum*.

26. Filaments up to 160 $\mu$ diam.; cells 3-5 diam. long. 21. *C. gracilis* v. *expansa*.

27. Ramuli straight; color light. 11. *C. flavescens*.

27. Ramuli curved; color dark. 13. *C. crispula*.

28. Frond of a spongy texture. 14. *C. flexuosa* f. *densa*.

28. Frond not of a spongy texture. 29.

29. Ramuli short, acute, spine-like. 7. *C. polyacantha*.

29. Ramuli not spine-like. 30.

30. Articulations long, up to 20 diam. 3. *C. Rudolphiana*.

30. Articulations not over 8 diam. long. 31.

31. Ramuli long, in pectinate series at tips of branches. 32.

31. Ramuli not in pectinate series at tips of branches. 33.

32. Branching patent; main filaments flexuous. 21. *C. gracilis* f. *australis*.

32. Branching erect; main filaments angular. 21. *C. gracilis*.

32. Branching very erect; fronds up to 1 meter long. 21. *C. gracilis* f. *elongata*.

33. Fronds light or pale green; plant of exposed rocky shores, No. Atlantic and Pacific. 14. *C. flexuosa*.

33. Frond light yellow-green; little known So. Atlantic species. 10. *C. luteola*.

34. Ramuli curved. 35.

34. Ramuli straight or nearly so. 38.

35. Frond of a spongy texture. 1. *C. albida* v. *refracta*.

35. Frond stiff and firm. 36.

36. Ramuli closely set throughout. 37.

36. Ramuli dense at tips only. 17. *C. scitula*.

37. Main branches 80 $\mu$ diam. or more. 23. *C. refracta*.

37. Main branches not over 50 $\mu$ diam. 24. *C. Bertolonii* v. *hamosa*.

38. Branches opposite or whorled. 29. *C. rupestris*.

38. Branches not opposite or whorled. 39.

39. Filaments not exceeding 30 $\mu$ diam. 1. *C. albida*.

39. Filaments over 30 $\mu$ diam. 40.

40. Ramuli acute; main filaments not over 60 $\mu$ diam. 2. *C. glaucescens.*
40. Ramuli not acute. 41.
41. Main branches virgate. 42.
41. Branching chiefly dichotomous. 45.
42. Cells of ramuli 1-2 diam. long. 43.
42. Cells of ramuli 4 diam. long or more. 44.
43. Main filaments about 50 $\mu$ diam. 4. *C. delicatula.*
43. Main filaments 80 $\mu$ diam. or more. 6. *C. brachyclados.*
44. Ramuli 20-30 $\mu$ diam. 8. *C. nitida.*
44. Ramuli 32-36 $\mu$ diam. 5. *C. virgatula.*
45. Branching continuously dichotomous, except as to ultimate ramuli. 9. *C. Stimpsoni.*
45. Main branching dichotomous; lesser branches and ramuli dense, largely secund. 19. *C. crystallina.*
46. Ultimate ramuli short, stout. 27. *C. laetevirens.* ✓
46. Ultimate ramuli long, slender. 20. *C. dalmatica.*

KEY TO THE FRESH WATER SPECIES OF CLADOPHORA.

1. Fronds floating, except in the early stages. 2.
1. Fronds permanently attached. 7.
2. Forming hard, globular masses. 52. *C. holsatica.*
2. Of no definite form. 3.
3. Main filaments stout, with short cells, bearing long, slender, secund ramuli. 50. *C. secunda.*
3. No sharp distinction between branches of different orders. 4.
4. Main filaments bent, cells ovoid or pyriform, branching patent. 47. *C. fracta.*
4. Main filaments straight or nearly so. 5.
5. Main filaments long, with few branches. 51. *C. insignis.*
5. Main filaments freely branching, branches with many ramuli. 6.
6. Ramuli mostly unicellular. 48. *C. oligoclona.*
6. Ramuli pluricellular, long-celled. 49. *C. crispata.*
7. Ramuli in dense terminal clusters. 8.
7. Ramuli not in dense terminal clusters. 10.
8. Ramuli recurved. 43. *C. declinata.*
8. Ramuli straight or slightly incurved. 9.
9. Lower branching mostly dichotomous; branches connate for some distance. 44. *C. canalicularis.*
9. Branching mostly alternate; branches not connate. 42. *C. glomerata.*
10. Not over 1 cm. high; fil. about 40 $\mu$ diam. 53. *C. uberrima.*
10. Larger, 10-40 cm. high; fil. 45 $\mu$ diam. or more. 11.
11. Main filaments 75-125 $\mu$ diam.; ramuli 35-50 $\mu$. 45. *C. callicoma.*
11. Main filaments 45-85 $\mu$ diam; ramuli 25-35 $\mu$. 46. *C. Kuetzingiana.*

1. C. ALBIDA (Huds.) Kützing, 1843, p. 267; Harvey, 1846-51, Pl. CCLXXV; 1858, p. 80; Farlow, 1881, p. 51; P. B.-A., No. 1227. Fronds soft, dense, pale green, filaments 20-30 $\mu$ diam., cells 4-5 diam. long, delicate; branching irregular, ramuli long, patent, blunt. Southern New England, Southern Cal. *Europe.*

The soft, spongy consistency and very slender filaments sufficiently distinguish the growing plant, and generally the dried specimen.

Var. REFRACTA (Wyatt) Thuret in LeJolis, 1863, p. 60; P. B.-A., No. 720; *C. refracta* Harvey, 1846-51, Pl. XXIV; 1858, p. 79. Upper branches and ramuli recurved; otherwise like the type. New Jersey to Maine. *Europe.*

In habit quite different from the type, but not in dimensions, etc. It seems to be commoner than the type, and to extend farther north on this coast. It shades into the type, and older specimens are liable to be mistaken for slender forms of *C. flexuosa;* in the growing plant the texture is sufficient for distinction, except from *C. flexuosa* forma *densa;* in this case the dimensions of cells must be depended on, as also in distinguishing from forms of *C. refracta.*

2. C. GLAUCESCENS (Griff.) Harvey, 1846-51, Pl. CXCVI; 1858, p. 77; Farlow, 1881, p. 52; P. B.-A., No. 817. Fronds 10-40 cm. long, glaucous or yellowish-green, loosely tufted, much branched, ending in long, erect, acute, alternate or sometimes secund ramuli; cells at base 50-60 $\mu$ diam., in ramuli 25-30 $\mu$; cells usually 4-6 diam. long, sometimes considerably longer. Florida to Labrador. *Europe.*

A plant of the litoral zone, and in the northern part of its range, a plant of spring and early summer. It is common in warm upper pools, exposed to the full sunshine, the upper part of the tuft fading almost to white. It grows also in marsh pools and shallow bays, where the water is warm.

3. C. RUDOLPHIANA (Ag.) Harvey, 1846-51, Pl. LXXXVI; 1858, p. 80; Farlow, 1881, p. 54; P. B.-A., No. 267. Fronds loose, soft, yellowish-green, gelatinous, up to a meter in length; main filaments 40-60 $\mu$ diam., branches alternate or opposite, patent, flexuous, ramuli secund, tapering, about 20 $\mu$ diam., cells always much longer than broad, sometimes up to 20 diam. long. Kennebunk, Maine to New Jersey, and probably farther south. *Europe.*

A plant of the upper sublitoral zone, growing in warm, shallow bays, often in large quantities. Apart from the microscopic characters, to which recourse must be had in mounted specimens, the growing plants can generally be distinguished from the nearest species, *C. albida* and *C. gracilis*, by the consistency of the frond. *C. albida* is soft and spongy ; *C. Rudolphiana* soft but not spongy ; *C. gracilis*, even in its most slender forms, has a certain harshness to the touch.

4. C. DELICATULA Montagne, 1850, p. 302 ; Kützing, 1856, Pl. I, fig. 2. Loosely tufted, soft, dull green, about 10 cm. high ; filaments 40-60 μ diam. below, 4-6 diam. long ; loosely branching, branches virgate, erect ; ramuli in short secund series, seldom over 8 cells in length, cells 20-30 μ diam., 1-2 diam. long ; joints somewhat constricted. Florida, Jamaica, Porto Rico, Cal. *South America*.

A delicate plant varying in the amount of ramification, and especially as to the frequency of the ramuli.

5. C. VIRGATULA Grunow, 1867, p. 38. Fronds 7-10 cm. high, soft, pale green, virgate, with subsimple main stem, beset with long, erecto-patent, subsecund branches, issuing from almost every joint ; connate for a short distance. Ramuli simple or with a few subsecund ramelli ; cells of main axis 75-110 μ diam., 3-6 diam. long ; of the ramuli 45-55 μ diam., 3-4 diam. long ; of the ramelli 32-36 μ diam., 2-3 diam. long ; terminal cells subtorulose. Guadeloupe.

The above is copied from Grunow's description ; the plant resembles *C. delicatula*, but is larger.

6. C. BRACHYCLADOS Montagne, 1838a, p. 15, Pl. IV, fig. 2 ; Harvey, 1858, p. 81. Filaments erect, 80-100 μ diam., primary branches long, patent, with numerous appressed ramuli ; ultimate ramuli very numerous, very short, secundly pectinate, 30-40 μ diam.; cells in main filaments 5 diam. long, in ramuli 2 diam.; nodes contracted. Cuba.

Resembling *C. delicatula*, but a larger plant, not so delicate, with joints more uniformly constricted ; *C. virgatula* also seems near it, but according to the description the latter has more abundant main branches and fewer ramuli.

7. C. POLYACANTHA Montagne, 1850, p. 302 ; *C. flexuosa* forma *Floridana* Collins, P. B.-A., No. 978. Tufts dull green, 10-20 cm. high ; filaments dichotomous below, 50-80 μ diam.; branches long, rather stiff, flexuous, usually with naked apex, elsewhere set with long similar branches, 30-50 μ diam., and

with numerous short, acute, spine-like ramuli, 25-35 $\mu$ diam., of two or three cells each. On rocks exposed to the waves, Florida. *So. America.*

Somewhat resembling *C. delicatula*, but stiffer, branches less erect, and usually more abundant; ramuli more acute, and not so distinctly secund.

8. C. NITIDA Kützing, 1843, p. 269; *C. trichocoma* Kützing, 1854, Pl. XXIX, fig. 2; Collins, 1901, p. 244. Fronds yellowish or whitish green, soft, dense, somewhat mucilaginous, usually up to 10 cm. high, occasionally much more; main filaments 50-100 $\mu$ diam., bearing more or less frequent straight, virgate branches, with alternate or secund, rarely opposite, erect branches of higher orders, and secund slender ramuli, 20-30 $\mu$ diam.; cells cylindrical, from 4-12 diam. long, usually over 6 diam. Jamaica, Bahama. *Europe.*

The fronds of this species are soft and slippery, often forming long, skein-like masses, similar to some species of *Rhizoclonium*. In the American specimens identified with this species, the filaments are more slender than in most European forms. In the north of Europe it seems to be stouter and harsher than with us; but some Mediterranean forms are soft and nearly as slender as the plants from Jamaica.

9. C. STIMPSONI Harvey, 1859a, p. 333; P. B.-A., No. 729. Fronds loosely tufted, up to 30 cm. high, light green, of delicate and silky texture; filaments 100-150 $\mu$ at base, tapering gradually upward, di- trichotomously divided, branches continuously but distantly forking, successively smaller, ultimate branches lateral, secundly pectinate with long ramuli, 20-25 $\mu$ diam., with rounded or slightly pointed tips. Cells 5-8 diam. long, longest near the base. On shells, etc. Southern California. *Japan.*

A soft, delicate, silky plant, reminding one of the more slender forms of *C. gracilis*, but distinct in manner of branching, substance and cell dimensions.

10. C. LUTEOLA Harvey, 1858, p. 81. Fronds pale yellow-green, tufted, very slender, much branched, not matted; very flexuous, with rounded angles; branching irregular, frequently trichotomous; ramuli secund or opposite, at the tip pectinate, somewhat corymbose and crowded; cells cylindrical, about 60 $\mu$ diam. in main branches, 35 $\mu$ in ramuli, 6-8 diam. long. Key West, Fla., Cuba.

11. C. FLAVESCENS (Roth) Kützing, 1843, p. 267; Harvey,

1846-51, Pl. CCXCVIII; *C. fracta* forma *flavescens* Collins, 1902, p. 124; P. B.-A., Nos. 1077, 1229. Filaments at first attached, later loose floating, 30-60 $\mu$ diam., forking at wide angles, cells 6-10 diam. long; ramuli not much smaller, tapering but with blunt tips; forming dense yellowish-green floating masses in high, warm pools. Mass. to N. Y. *Europe.*

This form occurs in high rock pools, where the water is quite salt; it has generally been considered a form of *C. fracta*, but is a smaller plant, attached in early stages, and inhabits strictly salt water.

12. C. CONSTRICTA Collins, 1909, p. 19, Pl. LXXVIII, figs. 4 and 5. Tufts dense, up 10 cm. high, somewhat fastigiate; main filaments up to 65 $\mu$ diam., branches smaller, ultimate ramuli about 25 $\mu$ diam.; cells 5-20 diam. long, mostly somewhat clavate, often with a distinct annular constriction about one diameter above the lower end. Branching mostly opposite below and often above, but also often lateral, the short ramuli somewhat secund; branches at first rather patent but soon curving upward; apex of terminal cell shortly conical with rounded tip.

In general appearance not unlike a small and dense form of *C. gracilis* such as is often seen in shallow pools on the north Atlantic coast, but the resemblance is merely external, the branching being more like that of *C. rupestris*. The cells vary much in length, but average quite long and usually increase slightly in diameter from base to summit. In the older parts the branching is quite regularly opposite or apparently trichotomous. The branching is quite dense, the outline usually regular. The constriction does not occur on all the cells, but is often very distinct, the diameter of the cell being reduced at this point to less than half the normal, the interior thickening of the cell walls contributing to this reduction; a slight manifestation of a character that is quite important in some Valoniaceae.

13. C. CRISPULA Vickers, 1905, p. 56; 1908, p. 19, Pl. XVI. Forming dark green spongy masses of contorted filaments, 45-50 $\mu$ diam., twisted in rope-like tufts; branches alternate or opposite, near the tips somewhat secund, curved; cells about 8 diam. long. Barbados.

Resembling in habit a *Chaetomorpha*, but with genuine branching.

14. C. FLEXUOSA (Griff.) Harvey, 1846-51, Pl. CCCLIII; 1858, p. 78; Farlow, 1881, p. 54; P. B.-A., Nos. 1076, 1527.

Fronds 10-20 cm. high, light green; main filaments 80-120 $\mu$ diam., regularly flexuous, with flexuous alternate branches, 40-80 $\mu$ diam., with alternate or secund, curved and sometimes refracted ramuli; cells from 6 diam. long below to 2 in the ramuli. Newfoundland to Bermuda and Florida, Alaska.

*Europe.*

A plant of nearly the same range on the Atlantic as *C. glaucescens;* it will probably be found on the Pacific to the south of Alaska. It occurs in rock pools, but usually near low water mark, and generally in colder places than *C. glaucescens.* It is a firmer plant, larger in all dimensions except total length of frond, and is distinctly flexuous throughout. On the other hand the larger forms of this species approach small forms of *C. gracilis*, *C. hirta*, and *C. laetevirens*, and it is often difficult to draw the line. Typical *C. gracilis* has long secund ramuli pectinately arranged at the end of every branch; *C. hirta* has rather shorter ramuli in secund series all along the filaments; *C. laetevirens* has short, stout ramuli in dense fascicles at the tip. By these characters normal forms can be distinguished without much difficulty. *C. flexuosa* Vickers, 1908, p. 19, Pl. XV, is hardly our plant; the figure is rather like a slender form of *C. gracilis.*

Forma DENSA Collins, 1902, p. 121; P. B.-A., No. 979. Branching of all orders very dense; texture of frond spongy. At lower limit of litoral zone. Newport, R. I.

Habit like *C. albida*, but form and dimensions of cells like *C. flexuosa.*

15. C. CRUCIGERA Grunow, 1867, p. 38. Fronds stout, pale green, rather loose, sparingly dichotomously branched; branches patent, connate for a short distance at the base; ramuli scattered, short, of few cells, alternate or oftener opposite, very patent; cells about 300 $\mu$ diam. below, 6-8 diam. long; ramuli 75-110 $\mu$, 3-4 diam. long, somewhat constricted at the nodes. Guadeloupe.

Grunow's description has been copied; he considers this a very distinct species, not to be mistaken for anything else.

16. C. EXPANSA (Mert.) Kützing, 1853, Pl. XCIX; Farlow, 1881, p. 55; P. B.-A., Nos. 121, 977, 1280. Fronds dull green, loosely branched, main branches 100-150 $\mu$ diam., flexuous, with smaller, patent, secondary branches, divaricately divided;

ramuli 40 $\mu$ diam., secund, blunt; cells 3-6 diam. long. In warm pools and lagoons. Newfoundland to New Jersey.
*Europe.*

Common in summer in marsh pools and lagoons where the temperature is high and the level varies little; at first attached, it soon rises to the surface, and ultimately forms a dense felty coating, continuous over large stretches of water, usually mixed with *Lyngbya aestuarii* and species of *Enteromorpha.* It will probably be found to extend in both directions beyond the limits given. Reports of *C. fracta* from marine stations probably should be referred to this species.

Var. GLOMERATA Thuret in Le Jolis, 1863, p. 61; P. B.-A., No. 1027. Ramuli in closely set tufts. Long Island Sound.
*Europe.*

The tufted ramuli give quite a distinct appearance; otherwise it is like the type.

17. C. SCITULA (Suhr) Kützing, 1849, p. 399; 1854, Pl. XII, fig. 1; *Conferva scitula* Suhr, 1831, p. 685; 1834, Pl. II, fig. 2. Frond small, brownish-green, stiff, densely fascicled; filaments erect, branching, branches erect, connate at the base, above recurved, with short, secund ramuli; lower cells 75-110 $\mu$ diam., 2-4 diam. long. W. I.

The figure by Suhr shows a small, perhaps immature plant with a few simple, slightly recurved branches and many short, secund ramuli; the figure by Kützing, apparently from an older plant, shows rather virgate main axes, densely set with somewhat secund branches; the ramuli at the ends of the branches arranged much as in *Ectocarpus fasciculatus.* The cells in the main axes are about 3 diam. long; in the ramuli 1-2 diam. long; the tips are blunt and rounded. The description above is from Kützing, and there is possibly a doubt as to the identity with Suhr's plant; if they are not the same, Kützing's had better stand for the species, as Suhr's figures and descriptions are hardly sufficient. There is no recent record of it.

18. C. BRACHYCLONA Montagne in Kützing, 1849, p. 394; 1853, Pl. XCVI, fig. 2. Fronds loosely tufted, pale green or yellowish, 10-15 cm. high; filaments di- polychotomous, 150-250 $\mu$ diam., in main divisions; branches at first distant, then more abundant; ramuli very short, often of a single cell, alternate, opposite or secund, 50-75 $\mu$ diam.; cells of main divisions

cylindrical, 4-6 diam. long; shorter in the branches, with constricted joints; in the ramuli ellipsoid, 1-2 diam. long. Bermuda. *Mediterranean.*

No authentic specimens have been accessible, but the Bermuda plant agrees so well with Kützing's figure that the identity seems fairly well assured.

19. C. CRYSTALLINA (Roth) Kützing, 1845, p. 213; 1854, Pl. XIX, fig. 2. Fronds yellowish or whitish-green, soft, glossy, 10-30 cm. high; filaments slightly matted, distantly di-trichotomously branched; main branches 80-140 $\mu$ diam., tapering to 25-40 $\mu$ in the ramuli; branching erect or patent; upper ramuli sometimes whorled or alternately secund; cells cylindrical, 4-12 diam. long. Mass., W. I. *Europe.*

A quite variable plant, but usually marked by its light color and silky gloss, which latter has given the specific names *crystallina*, *sericea* and *nitidissima* to various forms. The long cells, often as long in the ramuli as in the main filaments, are also characteristic. The plant distributed under this name as P. B.-A., No. 723, is probably not correctly determined. *C. sericea* Vickers, 1908, p. 18, Pl. XIV, may be a shorter jointed and divaricately branched form of this species, but has also considerable resemblance to the following.

20. C. DALMATICA Kützing, 1843, p. 268; Vickers, 1908, p. 19, Pl. XIV.B. Fronds up to 5 cm. high, light green; main filaments 80-120 $\mu$ diam., simple or distantly dichotomous below, trichotomous above, with many alternate or secund branches; cells 3-6 diam. long; ultimate ramuli corymbose, incurved, secund, 30-50 $\mu$ diam.; cells 1½-3 diam. long, nodes contracted, membrane thickish. Barbados. *Europe.*

21. C. GRACILIS (Griff.) Kützing, 1845, p. 215; Harvey, 1846-51, Pl. XVIII; 1858, p.80; Farlow, 1881, p. 55; P. B.-A., Nos. 1528, 1529, not No. 724. Fronds usually not over 30 cm. long, yellowish or glaucous green, somewhat harsh to the touch; main filaments up to 160 $\mu$ diam., irregularly bent, branching at the angles; the branches more slender, set at the tips with secund series of long, attenuate, acute ramuli, 40-60 $\mu$ diam.; cells 3-5 diam. long throughout. Greenland to Key West. *Europe.*

A variable species, passing into *C. laetevirens*, *C. hirta*, and *C. flexuosa;* see under the last for special distinctions. It assumes various forms under different environment and at different stages of growth, and until one is familiar with it, will often be very puzzling. The angular main stem and the pectinate terminal ramuli are the only constant marks to distinguish it from other species of the same general dimensions. It seems to be common from Massachusetts to Nova Scotia, both on exposed shores and in bays; more than most species of *Cladophora* it thrives in places where it is quite out of water at low tide. Several forms occurring on the New England coast have received names.

Var. VADORUM (Aresch.) Collins, 1902, p. 122; *C. gracilis* var. *tenuis* Farlow, 1881, p. 55; *C. vadorum* Wittr. and Nordst., Alg. Exsicc., Nos. 1045, 1046. Filaments more slender than in the type, 40-100 $\mu$, cells 4-8 diam. long. Forming loose, floating masses in the sublitoral zone, N. S. to N. J. *Europe.*

Forma ELONGATA Collins, 1902, p. 122; P. B.-A., No. 725. Frond stretching out on the surface of shallow water to a length of a meter or more; very glaucous green; branches distant and very erect. In shallow warm pools where there is a definite steady current; coast of Maine.

Forma EXPANSA Farlow, 1881, p. 55, as variety; P. B.-A., No. 981. Frond soon detached, forming loose floating masses, irregularly branched. Tide pools, coast of Maine and Massachusetts. Forming floating masses, similar to *C. expansa*, but not so dense.

Forma SUBFLEXUOSA Collins, P. B.-A., No. 1530. Fronds shorter than in the type, branching dense, branches flexuous. A somewhat reduced form of shallow rock pools in northern New England.

This form appears to originate in pools where the water is shallow, and there is no current; where the water is shallow and a current runs through when the tide is out, forma *elongata* is produced.

Forma **australis** n. f. Filaments less sharply angular; branches of all orders more patent. The common form south of Cape Cod; the opposite extreme from forma *elongata*, but connected by every gradation.

22. C. HIRTA Kützing, 1845, p. 208; 1854, Pl. I, fig. 2; P. B.-A., No. 726. Fronds 20-30 cm. high, stiff and harsh; filaments 150-200 $\mu$ diam. at base, dull green, much or little branched; all set throughout or frequently with short, subacute, more or less secund ramuli; cells 2-4 diam. long, rarely somewhat more. In rather exposed places, Greenland to Long Island Sound, and probably extending farther south. *Europe.*

In dimensions and general form somewhat like coarse *C. gracilis* of the northern type, but distinguished by ramuli generally distributed over the filaments, not merely at the tips. The amount of ramification varies much; the most characteristic forms have long, little branched filaments set with longer or shorter secund series of ramuli; the much branched forms are less characteristic, and require more careful examination.

23. C. REFRACTA (Roth) Areschoug, Alg. Exsicc. Scand., No. 338; Farlow, 1881, p. 52; P. B.-A., No. 573. Fronds tufted, glaucous or dull green, 10-20 cm. high; filaments rather stiff, 100-120 $\mu$ diam. below, 40-50 $\mu$ in the ramuli; cells 2-3 diam. long; branches of all orders at first erect, then reflexed; ramuli often secund, blunt. N. S. to N. J. *Europe.*

The regularly reflexed branches of all orders distinguish this from all our other species of the same range except some forms of *C. flexuosa* and *C. albida* var. *refracta*; the former is a more open plant, with flexuous rather than refracted branches; the latter has more slender filaments and softer substance. *C. refracta* has a characteristic habit, hard to describe, but fairly recognizable when once seen. For *C. refracta* Harvey, see *C. albida* var. *refracta*.

24. C. BERTOLONII var. HAMOSA (Kütz.) Ardissone, 1886, p. 242; *C. hamosa* Kütz., 1854, Pl. VIII, fig. 2. Tufts 3-10 cm. high, dark green; filaments rather stiff, 80-100 $\mu$ diam. in the main divisions, 25-30 $\mu$ in the ramuli; much branched, main divisions di-trichotomous, set with alternate, opposite or whorled branches, usually short, and with densely set, secund, recurved ramuli; cells 1⅓-3 diam. long, rarely more; terminal cells rounded, not tapering. Cal. *Mediterranean.*

The California plant seems to be more slender than the European, seldom exceeding 60 $\mu$ in the main branches and 25 $\mu$ in the ramuli. The dark color, short cylindrical cells and elegant feathery tips, with a long series of secund, usually slightly recurved ramuli on the similarly recurved branch, are fairly clear characters.

25. C. MICROCLADIOIDES Collins, 1909, p. 17, Pl. LXXVIII, figs. 2 and 3. Fronds more or less densely tufted, 10-20 cm. high; filaments about 200 $\mu$ diam. at base, cells 4-6 diam. long; stiff, straight or flexuous, distantly di-trichotomous, branches similar, erect or more or less recurved, bearing on the upper (inner) side numerous short branches, rarely with very short branches

opposite one or more of them; this ramification continued, the ultimate ramuli of very few cells, 80-100 $\mu$ diam., cells 1½-2½ diam. long. Cal.

A stout but graceful species, with a characteristic ramification like that of *Microcladia borealis* Ruprecht. There is considerable variation, according as the main divisions are straight or flexuous, the branches close or distant, erect or recurved; but the peculiar symmetrical ramification will distinguish it from any other of our species. As many as four cells may sometimes be found issuing from the much widened top of a cell, all flabellately arranged in one plane.

26. C. FASCICULARIS (Mert.) Kützing, 1843, p. 268; P. B.-A., Nos. 122, 1228, 1472; Vickers, 1908, p. 18, Pl. XIII; *Conferva fascicularis* Montagne, 1839, p. 4, Pl. VII, fig. 1. Fronds elongate, up to 50 cm. long; main filaments and principal branches flexuous, sparingly alternately branched, the ends beset with rather long, pectinate, more or less densely fasciculate ramuli; main filaments 200-250 $\mu$ diam., cells 2-4 diam. long; ramuli 80-120 $\mu$ diam., cells usually 1-2 diam. long. Florida, W. I. *So. America.*

A common and quite variable species, something of the range of variation being shown by the specimens distributed in P. B.-A.

27. C. LAETEVIRENS (Dillw.) Harvey, 1846-51, Pl. CXC; 1858, p. 82; Farlow, 1881, p. 53; *Conferva glomerata* Wyatt, Alg. Danm., No. 143. Filaments 50-150 $\mu$ diam., rigid, yellow-green, much branched; branches erect, often opposite; ultimate ramuli short, obtuse or subacute, densely fastigiate at the tips of the branches; fronds up to 20 cm. long; cells in main branches 6 diam. long, in ramuli 3 diam.

A stout and rather coarse species, best characterized by the dense tufts at the ends of the branches, formed of stout, blunt ramuli; it grows at the lower limit of the litoral or in the sublitoral zone, and is not a common species. The reports of this species from the west coast are all doubtful. Me., Mass.

28. C. HUTCHINSIAE (Dillw.) Kützing, 1845, p. 210; Harvey, 1846-51, Pl. CXXIV; Farlow, 1881, p. 53. Fronds glaucous green, up to 40 cm. high; filaments 120-300 $\mu$ diam., stiff, flexuous, sparingly branched; ramuli few, secund, blunt, with constricted nodes; cells 2-3 diam. long. Florida and W. I. to New Jersey; Vancouver Island. *Europe.*

The largest species of the North Atlantic coast, not to be mistaken for any other species occurring there. It has been reported from few localities, but is likely to be found at various points south of Cape Cod, and on the west coast south of Vancouver.

Var. DISTANS (Ag.) Kützing, 1849, p. 392; *C. diffusa* Harvey, 1846-51, Pl. CXXX; 1858, p. 83; *Conferva diffusa* Wyatt, Alg. Danm., No. 144. Main branches long, nearly bare of secondary branches; cells longer than in the type; nodes not constricted. Mass. to New Jersey. *Europe.*

Connected with the type by intermediate forms.

29. C. RUPESTRIS (L.) Kützing, 1843, p. 270; Harvey, 1846-51, Pl. CLXXX; 1858, p. 74; Farlow, 1881, p. 51; P. B.-A., No. 728. Fronds densely tufted, dark green; filaments stiff, 150 $\mu$ diam. at the base, 70-80 $\mu$ in the ramuli; cells 3-4 diam. long; branches opposite or in whorls of four, erect; ramuli short, blunt or subulate. Greenland to Gay Head, Mass. *Europe.*

A distinct species, growing usually on rocks in the litoral zone, especially in places covered by Fuci and other large algae; when growing it is a rich dark green, but in drying the color becomes duller and the plant seems coarse; it seems to be in as good condition in winter as in summer, while most Northern species of *Cladophora* are spring and summer plants.

30. C. OVOIDEA Kützing, 1843, p. 266; 1853, Pl. XCII, fig. 1. Fronds 5-15 cm. high, stiff, rather dull green; filaments distantly dichotomous, 150-200 $\mu$ diam. below, branches becoming more lateral and secund above; upper ramuli not over 60 $\mu$ diam, tips rounded or slightly pointed; cells in lower part cylindrical, 4-8 diam. long; above ovoid, 1½-3 diam. long. Santa Cruz, Cal. and vicinity. *Europe.*

This plant is often found in collections bearing the name of *C. cartilaginea*; but that species is probably a *Spongomorpha*.

31. C. UTRICULOSA Kützing, 1843, p. 269; 1853, Pl. XCIV, fig. 1; Wittr. and Nordst., Alg. Exsicc., No. 929. Fronds tufted, light or dull green, 10-20 cm. high; filaments firm, submembranaceous, di- polychotomous, 100-250 $\mu$ diam. near base, in upper part set with lateral, often secund ramuli, 70-100 $\mu$ diam.; cells 6-8 diam. long below, 2-4 diam. above. Jamaica, Bahama, Porto Rico., etc. *Europe, So. America.*

A species varying much in size, extent of branching, etc.

32. C. CATENATA (Ag.) Ardissone in Rabenhorst, Algen, No. 1293. Fronds densely tufted, dark green, stiff, up to 8 cm. high; filaments much branched, di- trichotomous below, 200-250 $\mu$ diam.; 80-150 $\mu$ in ramuli; cells 3-6 diam. long, nodes constricted; ramuli opposite, secund or irregularly placed, somewhat fasciculate; terminal cell usually obovoid. Jamaica. *Europe.*

Found throughout the Mediterranean, but so far reported at only this one locality in America. Somewhat like a more delicate *C. prolifera.*

33. C. CATENIFERA Kützing, 1849, p. 390; 1853, Pl. LXXXIII, fig. 1. Fronds stiff, cartilaginous or horn-like, flexuous, more or less densely branched, up to 50 cm. high; main filaments 300-500 $\mu$ diam. at base, alternately or sometimes oppositely branched, branches patent, the last series bearing opposite or alternate, more or less densely fasciculate ramuli, 100-225 $\mu$ diam.; cells in main stem long, up to 20 diam., cylindrical; in branches 8-10 diam., slightly constricted at nodes; in ramuli 1½-2 diam., oblong. Jamaica, Bermuda. *Cape of Good Hope.*

A noble plant in its larger forms, resembling mostly *C. pellucida*, under which name it has sometimes been reported. That species, however, is quite regularly di- polychotomous, branching at the top of each cell. *C. catenifera* varies much as to its rigidity or softness, and as to the density of the fascicles of ramuli; but the other characters seem to be quite permanent.

34. C. GRAMINEA Collins, 1909, p. 19, Pl. LXXVIII, fig. 6. Loosely tufted, 10-15 cm. high, dark green, cartilaginous, distantly di- trichotomous, all divisions erect; main filaments about 300 $\mu$ diam., ultimate divisions about 150 $\mu$ diam., tips blunt or slightly acute; cells very long below, up to 30 diam., shorter above; normally occupying the space from one forking to another; ultimate branches 4-6 diam. long; cell walls usually strongly striate. Cal.

Distinguished from all our other species by the long cells, each normally extending from one forking to the next; in this it agrees with *C. pellucida* (Huds.) Kütz. of Europe, but in the latter there is more reduction of size in the successive orders of branches, the main filament being sometimes as large as 500 $\mu$ diam., while the ultimate ramuli are seldom over 50 $\mu$, and are dense and more or less fasciculate. In *C. graminea* there is comparatively little diminution in size, and the tips are loose and open. In *C. pellucida* the divisions of the di- or trichotomy are usually equal and develop equally; in *C. graminea* one is often much reduced, sometimes only a single cell.

35. C. PROLIFERA (Roth) Kützing, 1845, p. 207; 1853, Pl. LXXXII, fig. 3; Vickers, 1908, p. 18, Pl. XII; Wittr. and Nordst., Alg. Exsicc., No. 1043. Fronds dense, dark green when growing, blackish when dried, up to 20 cm. high, rarely more; filaments coarsely membranaceous or cartilaginous, 300-400 $\mu$ diam., di-trichotomous, divisions mostly erect, more frequent towards the somewhat fastigiate tips; ramuli 130-200 $\mu$ diam., blunt; cells up to 20 diam. in main filaments, much shorter in the branches, 4-6 diam. long in the ramuli. In lower litoral zone and in shallow water, Porto Rico, Barbados.

*Europe.*

A coarse, dark colored, rather unsightly plant, common in the Mediterranean, and generally in the warmer Atlantic.

36. C. FULIGINOSA Kützing, 1849, p. 415. Forming large, dark brownish-green tufts; filaments hard, stiff, more or less densely matted, 150-160 $\mu$ diam.; cells cylindrical, 5-10 diam. long; the main axes long, set with short, blunt ramuli, often in secund series. Florida, W. I.

This species was described from Cuban specimens, and has apparently never been since reported. The writer is indebted to Dr. Bornet for calling his attention to the fact that it is apparently the same as the *Cladophora* that, in combination with an endophytic fungus, *Blodgettia Borneti* Wright, 1881, p. 21, Pl. II, figs. 1-4, makes up the *Blodgettia confervoides* Harvey, 1858, p. 48, Pl. XLV.C, and which was distributed under the last name as P. B.-A., No. 314. The hyphae of the fungus may possibly occur in connection with some other species of *Cladophora*, but in all specimens observed the host agrees fairly well with the description of *C. fuliginosa*.

37. C. MAGDALENAE Harvey, 1846-51, Pl. CCCLV.A; Farlow, 1881, p. 56; P. B.-A., No. 572. Fronds short, coarse, dull green, 60-100 $\mu$ diam., matted, procumbent, with patent, flexuous branches, bearing a few irregularly placed, curved ramuli; cells 2-4 diam. long. R. I. and Conn. *Europe.*

A coarse, unsightly plant, creeping in tangled masses among other algae in the litoral zone, in late autumn and winter. Not a well understood species, and perhaps it may some time prove to be a winter form of something else.

38. C. HOWEI Collins, 1909, p. 18, Pl. LXXVIII, fig. 1. Forming dense matted tufts, consisting of creeping basal filaments, with irregular cells about 150 $\mu$ diam., tapering to 75 $\mu$ at the growing tips, cells 1-3 diam. long; from these basal filaments arise vertical filaments about 50 $\mu$ diam. at base, tapering to 20-25 $\mu$ at the rounded or slightly pointed tip; cells about 5-6 diam. long at the base, up to 15-20 diam. long near the tip; sparingly branched, branches erect or appressed, similar to the erect filaments. Bermuda.

Forming a dense coating in tide pools, about 1 cm. high; the base a mat of dark green, much branched, irregular filaments, from which arise the slender, slightly branched, long-jointed filaments, pale green under the microscope, yellow in the mass. This yellow color may not be a permanent character, as the same shade appears to be produced by local conditions in some algae normally green. The contorted, densely matted basal filaments indicate an affinity to the sub-genus *Aegagropila*, but there is no indication of a definite form to the whole mass.

39. C. TRICHOTOMA (Ag.) Kützing, 1849, p. 414; 1854, Pl. LXIV, fig. 1; P. B.-A., No. 820; *C. repens*, P. B.-A., No. 727, not of Harv.; *C. columbiana* Collins in Setchell and Gardner, 1903, p. 226. Forming light or bright green, densely pulvinate masses, 2-5 cm. high; filaments procumbent at base, stiff, di-trichotomous with rather few short, alternate, rarely opposite branches, fastigiate at the tips; cells 120-250 $\mu$ diam., 4-10 diam. long, nearly cylindrical below, above ovoid to pyriform; the branches about the same diameter as the filament. Vancouver Island to Southern Cal. *Europe.*

In habit like *C. repens*, but of lighter or brighter color and larger cells. It grows in rock pools near high water mark, and has been found from Vancouver to the Mexican boundary. It seems impossible to draw any sharp line between *C. trichotoma* and *C. columbiana*; the form distributed as *C. repens*, P. B.-A., No. 727, differs so much from the Mediterranean plant that it seems best to include it under the present species.

40. C. AMPHIBIA Collins, 1907, p. 200; P. B.-A., No. 1284. Basal layer of densely branching prostrate filaments, cells cylindrical, 40-70 $\mu$ diam. and 2-5 diam. long, or fusiform, 1-2 diam.

long, swollen to 100 $\mu$ in the middle; emitting erect filaments, cells 30-50 $\mu$ diam., 4-8 diam. long, cylindrical or irregular, terminal cell obtuse or truncate; slender descending rhizoids sometimes issuing from lower cells of erect filaments. Cal.

A dull green, unattractive plant, growing near extreme high water mark, among *Salicornia*, in a salt marsh, and having much the habit of *Vaucheria*.

41. C. INTERTEXTA Collins, 1901, p. 243; P. B.-A., No. 818. Tufts densely matted, prostrate; filaments 300-350 $\mu$ diam., creeping over shells and sand; cells 1-1½ diam. long, rarely up to 3 diam.; bearing upright branches, about 200 $\mu$ diam., simple or with a few short, secund ramuli; terminal cells blunt. Jamaica.

Forming dense, tangled masses in the bottom of pools; the naked branches projecting, giving the whole the appearance of a tangled mass of *Chaetomorpha*.

42. C. GLOMERATA (L.) Kützing, 1845, p. 212; P. B.-A., No. 1283. Fronds up to 30 cm. high, more or less densely branched below, branches more and more frequent towards the top, at last forming dense fascicles; filaments cylindrical, 75-100 $\mu$ diam. below, 6-7 diam. long; 35-50 $\mu$ diam. in the ramuli, 3-6 diam. long; ramuli not tapering, tips rounded; fruiting cells terminal or subterminal. Fig. 124.

An extremely variable species and not marked by any distinct lines from the four following species. Specimens distributed in P. B.-A., No. 1283, correspond fairly with the typical form; the plant distributed as *C. glomerata*, P. B.-A., No. 473, belongs rather in forma *rivularis*; No. 278, Tilden, American Algae, is a quite elongate form; a plant from the Mississippi River, Winona, Minn., comes nearer to the type than to any of the following varieties, and Tilden, American Algae, No. 35, *C. callicoma*, probably belongs here. Wolle gives few definite localities; some specimens marked by him *C. glomerata* have been examined, but they are very imperfect and uncharacteristic. No. 32, Tilden, American Algae, is distributed as *C. glomerata* var. *fasciculata* Rab.; the only character distinguishing this from the type is found in the swollen terminal cells; but as this appears to be due to the formation of spores, and is probably the same throughout the species, the varietal name seems unnecessary. Var. *clavata* Wolle, 1887, p. 128, appears also to be merely a fruiting state of some *Cladophora*; the specimen distributed under this name in Tilden, American Algae, No. 34, was sterile in the copy examined, and characterless.

Forma RIVULARIS Rabenhorst, 1868, p. 341; P. B.-A., No. 473; Tilden, Amer. Algae, No. 33. Frond elongate, more open, fascicles of ramuli rather distant. Housatonic River, Conn.; San Leandro, Cal.

Forma MUCOSA Kützing, 1849, p. 406; Tilden, Amer. Algae, No. 537. Soft and mucilaginous; color deep green. Niagara Falls, Lake Ontario, Charlotte, N. Y.; Minn.

43. C. DECLINATA Kützing, 1849, p. 406; 1854, Pl. XXXV. Fronds usually loosely branched, with lateral and terminal glomerules of recurved ramuli; cells of main branches cylindrical, 80-100 $\mu$ diam., 3-10 diam. long; of ramuli 50-60 $\mu$ diam., swollen and often variously distorted. California.

*Europe.*

In habit somewhat resembling the marine *C. refracta*. The Californian specimens have long, subsimple branches with quite long cells, and set at intervals with tufts of curved and more or less distorted ramuli. *C. glomerata* var. *parvula* Bailey in Rabenhorst, Algen, No. 520; Wolle, 1887, p. 128, is made a form of this species by Rabenhorst, 1868, p. 340. A specimen distributed under this name in Tilden, American Algae, No. 37, hardly shows the characters of this species. No. 38 of the same distribution, *C. declinata* var. *fluitans* (Kg.) Hansg., 1886, p. 84, does not have the characters indicated by Hansgirg.

44. C. CANALICULARIS (Roth) Kützing, 1845, p. 214; 1854, Pl. XLIII, fig. 1; Wolle, 1887, p. 126. Fronds 5-10 cm. high, much branched, branching mostly di- trichotomous, branches connate at the base; ramuli often fasciculate; main filaments 85-120 $\mu$ diam., cells 5-8 diam. long; cells in branches shorter, in ramuli 1-1½ diam. long, 35-50 $\mu$ diam., somewhat swollen; cell membrane usually thick.

While no definite localities can be given, it is probable that this species occurs with us; it seems to be little more than a rather coarse *C. glomerata*. The occurrence of connate branches is not uncommon in various species of *Cladophora*, both fresh water and marine, and the length of the cells is a very uncertain character. Wolle's figures, Pl. CXI, figs. 1 and

2, are not clear enough to justify his determinations; No. 143, Tilden, American Algae, does not show the characters of the species. This 143 is given as *C. canalicularis* (Roth) Kg. var. *genuina* Rabenh., 1868, p. 342; no such combination appears on that page, or apparently elsewhere in the work.

45. C. CALLICOMA Kützing, 1843, p. 267; 1854, Pl. XXXVII, fig. 1; Rabenhorst, Algen, No. 2166. Forming rather dense, soft tufts, up to 30 cm. high; filaments 75-125 μ diam. below, 35-50 μ in the ramuli; cells cylindrical or slightly inflated below, distinctly inflated in the ramuli, 6-8 diam. long below, 2-4 in the ramuli; branching subdichotomous below, then alternate, and in the ramuli alternate or somewhat secund; tips rounded. Housatonic River, Conn.; Long Brook, Princeton, N. J.; Montana.

Forming soft tufts in streams; usually quite dense, but the tips penicillate rather than glomerate. An authentic specimen, received by the kindness of Dr. Bornet, shows dimensions larger than those usually given; the specimens distributed under this name as Nos. 25 and 919 P. B.-A., seem to be rather *C. Kuetzingiana* Grunow. A plant from Watkins' Glen, N. Y., agrees well with this species; Wolle records *C. fluitans* from this locality, but the specimen just mentioned is evidently not that species.

46. C. KUETZINGIANA Grunow in Rabenhorst, 1868, p. 342; *C. callicoma* P. B.-A., Nos. 25, 919. Forming soft, rather loose and feathery tufts up to 30 cm. high; filaments 45-85 μ diam. below, ramuli 25-35 μ diam.; cells cylindrical or in the ramuli slightly swollen; 6-10 diam. long below, occasionally longer; 2-4 diam. long in the ramuli; branching erect, opposite or alternate below, but the ramuli generally secund, rather long and tapering, with acute or subacute tips. Still River, Conn.; Lake Washington, Seattle, Wash.

A large but delicate species, with long, feathery tufts; growing in lakes and rivers. It appears to be the *C. macrogonya* of Kützing, but not of Rabenhorst, Algen, No. 2384, nor the *Conferva glomerata* var. *macrogonya* of Lyngbye, 1819, Pl. LIII.

The following forms seem to belong under *C. Kuetzingiana*, as here understood: —

*C. glomerata* var. *callicoma* forma *Boreali-Americana* Brand in Tilden, American Algae, No. 536. Primary filaments generally connate at the base; filaments 63-70 $\mu$ diam. below, ramuli 20 $\mu$; cells 8-15 diam. long. Minn.

*C. glomerata* var. *callicoma* forma *Minnesotana* Brand in Tilden, American Algae, No. 538; P. B.-A., No. 1379. Glomerules not conspicuous, branches seldom connate; filaments 70-80 $\mu$ diam., ramuli 17 $\mu$; cells 5-8 diam. long. Minn., California.

47. C. FRACTA (Dillw.) Kützing, 1843, p. 263; 1854, Pl. L.; Wolle, 1887, p. 124; P. B.-A., Nos. 120, 816, 1281, 1282. Fronds forming loose, floating masses, usually of a dark green color; branching irregular, filaments much bent and curved; main filaments 60-120 $\mu$ diam., cells 1-3 diam. long; ramuli 20-40 $\mu$ diam., cells 3-6 diam. long; cells seldom cylindrical, mostly ovoid, clavate or irregular; fruiting cells never terminal.

A species of world-wide distribution, taking on innumerable shapes which have received names as forms, varieties and species; one of these is retained here as a species in the same way as four are retained in connection with *C. glomerata*, but with much doubt as to their representing distinct specific types.

Forma GOSSYPINA (Kütz.) Rabenhorst, 1868, p. 335; Algen, No. 2576; Wolle, 1887, p. 125; Tilden, American Algae, No. 141. Filaments slender, sparingly branched; forming dense, interwoven, silky masses. Pa., Idaho. *Europe.*

Form SUBSIMPLEX Kützing, 1845, p. 218. Filaments very slightly branched; easily mistaken for a *Rhizoclonium.* Mass. *Europe.*

Forma RIGIDULA (Kütz.) Rabenhorst, 1868, p. 335. Filaments stout and stiff, loosely branched. Conn. *Europe.*

Forma REFLEXA Collins, P. B.-A., No. 1194. Main branches stout, flexuous; branches of higher orders patent or reflexed, often in secund series. Cal.

Forma STREPENS (Ag.) Rabenhorst, 1868, p. 335; *C. strepens* Kützing, 1854, Pl. XLVIII, fig. 2; *C. fracta* var. *calcarea* Tilden, American Algae, No. 142. Branching irregular; main filaments 90-125 $\mu$ diam.; ramuli 25-40 $\mu$; cells cylindrical or swollen, varying in length from 1 to 6 diam. in the same filament; the whole plant more or less incrusted with lime. So. Dakota. *So. Europe.*

48. C. OLIGOCLONA Kützing, 1845, p. 218; 1854, Pl. LIV. Filaments sparingly branched, pale or dirty green; main filaments mostly dichotomous, secondary filaments elongate, beset with short, mostly unicellular ramuli; cells cylindrical to

slightly clavate, in the main branches 2-6 diam. long, 45-55 μ diam.; in the ramuli 4-10 diam. long, 30-40 μ diam. *Europe.*

Both the type of this species and the var. *Flotowiana* are given by Wolle, 1887, p. 126, as occurring "in stagnant water" and it is quite probable that this species occurs here, though no certain specimens have been seen. Tilden, American Algae, No. 29, in the specimen examined is quite insufficient and undeterminable. The label gives the diam. of the main cells as 75 μ, of the branches as 43 μ; considerably above the figures given by Wolle or Kirchner. No. 30 of the same distribution is labelled *C. oligoclona* Kg. var. *flotowiana* (Kg.) Hansg. Prodr. 81, and the filaments are stated to be 15 μ diam.; an examination of the specimen shows that they are really 60 μ diam. in the main branches. Hansgirg gives dimensions for the same 40-56 μ. The confusion is such that no conclusion can be drawn from Miss Tilden's specimens or Wolle's descriptions and figures.

49. C. CRISPATA (Roth) Kützing, 1843, p. 264; Wolle, 1887, p. 126. Forming loose masses; main filaments sparingly branched laterally or dichotomously; branching above alternate, more dense, and filaments more slender in each order of branches; main filaments 40-75 μ diam., in some varieties somewhat more; in ramuli 20-35 μ; cells cylindrical, 5-20 diam. long, usually proportionally longer in the ramuli than in the main filaments; ramuli not tapering, rounded at the end; cell wall thin and delicate.

The very long, slender filaments with erect branches gradually decreasing in size, with long, delicate cells, make this a fairly distinct species. Many varieties have been described, but they are rather vague in their distinctions.

Forma VITREA (Kütz.) Rabenhorst, 1868, p. 336; Algen, No. 1529; Kützing, 1854, Pl. XL, fig. 1. A delicate pale form, with long cells; Iowa. The plant distributed under this name in Tilden, American Algae, No. 277, seems to be rather *C. Kuetzingiana* Rab.

As No. 2570, Rabenhorst, Algen, is distributed under the name of *C. crispata* Roth h. *virescens* Forma *thermalis* Brügg., a plant from Bethlehem, Pa., rather shorter-jointed than usual for this species.

As P. B.-A., No. 1193, is distributed a very long and sparingly branched plant from California, under the name of *C. cris-*

*pata* forma *subsimplex* Collins. It is quite close to forma *longissima* (Kütz.) Rabenhorst, 1868, p. 337. This form seems to be quite common in California; the fronds remaining attached to stones, etc. in running water until they have reached their full growth, sometimes as much as a meter; the branching is rather distant, the ramuli are short, with cells 4-8 diam. long.

50. C. SECUNDA Kützing, 1849, p. 411; P. B.-A., No. 1230. Forming dense masses; main filaments elongate, sinuous, sparingly branched alternately or subdichotomously; bearing long secund series of ramuli, normally one from each cell of the filament; long below, becoming gradually shorter towards the tip; cells in main filaments and branches 90-125 $\mu$ diam., 3-5 diam long, cylindrical or somewhat contorted; in ramuli 20-40 $\mu$ diam., 4-8 diam long, cylindrical or slightly swollen; ramuli tapering to the subacute tip. California. *Europe.*

No authentic specimen of this species being accessible, there is naturally some doubt as to the identification; the Californian plant formed floating masses in a watering trough at No. Berkeley, Cal., while Kützing's plant, though included by him among the fresh water algae, was found by Suhr in brackish water in Denmark. The description agrees well with the plant, and there seems to be no other described species in which the latter could be included; to avoid making a new species, the present name is applied. In our plant there is a remarkable contrast between the coarse cells of the large filaments and the delicate cells of the ramuli; it seems like young plants of *C. crispata* growing out of old, battered stems of *C. fracta*, and emphasizes our lack of knowledge of any of these species, through all their life history.

51. C. INSIGNIS (Ag.) Kützing, 1845, p. 217; 1854, Pl. XXXVIII, fig. 1; P. B.-A., No. 868. Forming extensive strata; filaments straight or nearly so, usually very little branched, 75-120 $\mu$ diam.; branches down to 40 $\mu$ diam.; cells 4-6 diam. long, somewhat swollen. In quiet water, California. *Europe.*

Fairly distinct by the stout, straight, little branched filaments. Our plant seems to belong to the type, but any of the numerous varieties may be expected.

52. C. HOLSATICA Kützing, 1849, p. 414; *C. aegagropila* P. B.-A., No. 164. Forming by the dense and irregular branch-

ing, spherical masses, 1-3 cm. diam., lying loose on the bottom, or slightly attached by rhizoidal growths; filaments about 45 $\mu$ diam. at base, up to 90 $\mu$ in the main branches, ramuli 45 $\mu$, terminal cells clavate or blunt-lanceolate, often swollen near the tip; cells mostly somewhat larger at the top than at the base; branches quite irregularly placed, densely packed. Mass.

*Europe.*

In the only reported American locality, this species was washed ashore in the form of small, hard, globular masses, each a densely branched individual. Other forms of the *Aegagropila* type probably occur, but no definite reports are to be had.

53. C. UBERRIMA Lambert ms.; P. B.-A., No. 1531. Frond minute, seldom over 1 cm. high, attached below by short, irregular, branching filaments; main filaments 30-50, rarely 60 $\mu$ diam., cells 3-10 diam. long; densely branched, branches opposite or alternate, erect or patent, issuing from any part of a cell; the first cross wall either at the base of a cell or higher up; erect branches often connate with each other or with the main stem for some distance; ultimate ramuli straight or curved, 15-20 $\mu$ diam., cells 5-10 diam. long; terminal cell slightly attenuate, with rounded apex. Production of zoospores and gametes very abundant, in terminal or intercalary cells, in all parts of the frond; new growth from cell below often passing through the empty sporangium.

A rather anomalous species, presenting some remarkable peculiarities; this notice is merely preliminary; a detailed account of the plant is soon to be published by Professor Lambert, who has had it under culture at the Botanical Laboratory of Tufts College.

Among the doubtful species of *Cladophora* must be reckoned the following.

*C. trinitatis* Kützing, 1849, p. 420.

*C. Morrisiae* Harvey, 1858, p. 78, Pl. XLV.B.

*Aegagropila Montagnei* Kützing, 1849, p. 415; 1855, p. 14, Pl. LXV, fig. 2.

*Spongopsis saccata* Kützing, 1849, p. 380; 1853, p. 17, Pl. L, fig. 1.

4. SPONGOMORPHA Kützing, 1843, p. 273.

Fronds of branching, monosiphonous filaments, larger at the tip than below, terminal cell longer than other cells, intercalary cell division general, cells other than terminal usually short; special descending rhizoidal branches, or special spine-like or hooked branches present, more or less matting the tufts together; cells in one species uninucleate. Otherwise as in *Cladophora*. Marine.

The special branches give this genus a higher rank than that of *Cladophora*, and the predominance of intercalary cell division also distinguishes it. The species are most abundant in arctic waters, not extending south beyond the temperate zone. The species from the Atlantic here included in *Spongomorpha* would be placed by Scandinavian authors under *Acrosiphonia*, following the monograph of that genus by Kjellman, 1893, except that if Wille, 1899a, is followed, the multinucleate species are included in *Acrosiphonia*, and *Spongomorpha* is used only for the uninucleate *Cladophora lanosa*. In Jónsson, 1904, the algae of East Greenland are thus divided, but the old specific names *arcta* and *lanosa* disappear entirely, *Acrosiphonia incurva* and *Spongomorpha vernalis* appearing instead. It is hard to see what principle justifies this. *Spongomorpha* dates to Kützing, 1843; *Acrosiphonia* to J. G. Agardh, 1846; the specific names *incurva* and *vernalis* are of Kjellman, 1893, while *arcta* dates from Dillwyn, 1809, and *lanosa* from Roth, 1806.

KEY TO THE SPECIES OF SPONGOMORPHA.

| | | |
|---|---|---|
| 1. Spinous or hooked branches present. | | 2. |
| 1. Spinous or hooked branches wanting. | | 4. |
| 2. Branches not spinous; tufts little matted. | 1. | *S. duriuscula*. |
| 2. Branches spinous; mature tufts densely matted. | | 3. |
| 3. Filaments 100 $\mu$ diam. at tip. | 6. | *S. spinescens*. |
| 3. Filaments 200 $\mu$ diam. at tip. | 7. | *S. coalita*. |
| 4. Filaments 200-500 $\mu$ diam. at tip. | 2. | *S. hystrix*. |
| 4. Filaments less than 150 $\mu$ diam. at tip. | | 5. |
| 5. Main filaments and branches obtuse. | | 6. |
| 5. Main filaments and branches blunt-pointed. | 5. | *S. saxatilis*. |
| 6. Filaments 30-40 $\mu$ diam. | 3. | *S. lanosa*. |
| 6. Filaments 60-100 $\mu$ diam. | 4. | *S. arcta*. |

1. S. **duriuscula** (Rupr.) nov. comb.; *Cladophora alaskana* Collins in Setchell and Gardner, 1903, p. 228; P. B.-A., No. 917. Tufts 15-25 cm. high, erect, main filaments firm, straight, with thick, striate walls, 200-250 $\mu$ diam. below, 300 at tip; articulations ½-1½ diam. long, 2-3 diam. at the blunt tips; branches similar, erect, scattered or in secund series of two or

more; near the base of the tuft more slender, 150-200 $\mu$ diam., with thinner walls, not striate, with numerous short, patent or recurved ramuli, scattered or secund. On stony beaches, lower litoral and upper sublitoral. Alaska.

A coarse species, but not matted like most species of *Spongomorpha*; it might be a question whether it belongs in this genus or in *Cladophora*; but the filaments usually larger at the tip, never tapering, the cells short below, longer above, indicate the present genus. Since the publication of *Cladophora alaskana* it has been possible to examine authentic specimens of Ruprecht's *Conferva duriuscula*, and there is no doubt of the identity; Ruprecht's description, however, is so scanty that no decision was possible from it; De Toni placing the species in *Chaetomorpha*.

2. S. HYSTRIX Strömfelt, 1887, p. 54; *Cladophora hystrix* P. B.-A., No. 982. Fronds rich green, in rather dense tufts, filaments straight, very erect, except those at the base of the tuft, which are somewhat more open; about 100-300 $\mu$ diam. at the base, 200-500 $\mu$ diam. at the tip; cells up to 4 diam. long at the tip, ½-1½ diam. long below; rhizoidal branches fairly common in the older parts, 40-70 $\mu$ diam., cells 3-10 diam. long.

Resembling *S. arcta*, but stouter and with shorter cells; a distinctly arctic species, found on the Massachusetts coast only in a reduced form, while *S. arcta* is practically the same in Greenland as in Long Island Sound. Three forms are reported from Greenland.

Forma **typica** (Jónsson) nov. comb.; *Acrosiphonia hystrix* forma *typica* Jónsson, 1903, p. 368. Fronds up to 15 cm. high, filaments 300-500 $\mu$ diam., not much entangled.

Forma **littoralis** (Jónsson) nov. comb.; *Acrosiphonia hystrix* forma *littoralis* Jónsson, 1903, p. 370. Tufts 4-10 cm. high, filaments 200-300 $\mu$ diam., considerably entangled.

Forma **debilis** (Rosenv.) nov. comb.; *Cladophora arcta* forma *debilis* Rosenvinge, 1893, p. 908. Tufts not over 10 cm. high, with few long branches, but many short, subsimple, often secund branches, of about equal length.

3. S. LANOSA (Roth) Kützing, 1849, p. 420; *Cladophora lanosa* Harvey, 1846-51, Pl. VI; 1858, p. 76; Farlow, 1881, p. 51; P. B.-A., No. 661. Fronds fastigiate, erect, light green, not over 5 cm. high, 30-40 $\mu$ diam., branches erect, usually arising some distance below top of cell; cells uninucleate, 2-6

diam. long, more or less matted at the base by descending rhizoidal filaments, slightly smaller than the main filaments. On various algae. Greenland to Conn. *Europe.*

A spring plant, forming very regular rounded tufts on various algae, the tufts becoming detached as the plant matures. It is noteworthy as having only one nucleus to a cell, while as far as observed all other species of *Spongomorpha* and *Cladophora* have normally two or more nuclei. It is possible that some of the Alaskan species may also be uninucleate, but no certainty can be had from dried specimens. On the other hand, single uninucleate cells are occasionally, though rarely, found in other species; and as apart from this character this species is in everything conformable to *Spongomorpha*, it does not seem necessary to institute a separate genus for it.

Var. UNCIALIS (Fl. Dan.) Kjellman, 1883, p. 306; *Cladophora uncialis* Harvey, 1846-51, Pl. CCVII; 1858, p. 77; *C. lanosa* var. *uncialis* Farlow, 1881, p. 51; P. B.-A., No. 77. Tufts irregular in outline, growing on rocks, not floating away when mature, but persistent in a coarse and faded state. Me. to Conn. *Europe.*

4. S. ARCTA (Dillw.) Kützing, 1849, p. 417; *Cladophora arcta* Harvey, 1846-51, Pl. CXXXV; 1858, p. 75; Farlow, 1881, p. 50; P. B.-A., Nos. 224, 815. Fronds rich green, in dense fastigiate tufts, up to 15 cm. high; filaments erect, stiff, 60-100 $\mu$ diam. at tips, cells 4-6 diam. long; below smaller, cells 1½-3 diam. long; much branched, branches erect or appressed, obtuse or clavate; rhizoidal descending branches 40-60 $\mu$ diam., cells 2-6 diam. long, firmly matting together the lower part of the tuft. On exposed rocky shores in spring. Greenland to N. J.; Alaska to Wash. *Europe.*

A common plant, the rounded rich green tufts being very handsome while the plant is young; later it becomes coarse and faded.*

Forma **conglutinata** nov. comb.; *Cladophora arcta* forma *conglutinata* Collins in Setchell and Gardner, 1903, p. 225. Filaments adhering in pointed, Symploca-like tufts; patent acute branches occasionally found at the base of older plants. Alaska to Wash.

*Var. *penicilliformis* Foslie in Wittr. and Nordst., Alg. Exsicc., No. 613, a rather slender form with terminal sporangia, is doubtfully reported from Greenland, Rosenvinge, 1893, p. 908; Jónsson, 1904, p. 49.

Forma PULVINATA Foslie, 1890, p. 130; *Cladophora arcta* forma *pulvinata* P. B.-A., No. 918. Filaments short, of uniform length, forming level-topped pulvinate masses. Alaska.
*Northern Europe.*

5. S. **saxatilis** (Rupr.) nov. comb.; *Cladophora saxatilis* Setchell and Gardner, 1903, p. 223; P. B.-A., No. 921. Fronds dense but not much matted together; filaments 80-120 $\mu$ diam., about the same diam. throughout, cells below 1-3 diam. long, above 3-6 diam.; terminal cell sometimes 10-12 diam.; branching di- trichotomous, with occasional lateral branches, divisions erect, somewhat acute or tapering, but with rounded tip; older parts with descending rhizoidal filaments, about half the diam. of the filaments from which they spring, and with longer cells, sometimes 10-12 diam. long. Alaska to Wash.
*Kamtschatka.*

Varying considerably in size of filaments, length of cells, erect or patent branches, but on the whole with longer cells than most of the species of *Spongomorpha*. The branches increase little if any in size towards the end, and the terminal cell is not sharply truncate. The four species of Ruprecht, 1856, *Conferva Chamissonis*, *C. Mertensii*, *C. viminea* and *C. saxatilis*, seem to be merely varieties, forms or states of growth of one species, *C. saxatilis* representing stouter or older forms, *C. Chamissonis* more delicate; the two other species range between. Little could be known from Ruprecht's short descriptions, but authentic specimens in Herb. Farlow justify the present arrangement.

Var. **Chamissonis** (Rupr.) nov. comb.; *Cladophora Chamissonis* Harvey, 1858, p. 75; P. B.-A., No. 920. Filaments 40-60 $\mu$ diam., cells 3-4 diam. long, nodes constricted; cells slightly shorter towards the base. Alaska to Wash.
*Kamtschatka.*

Smaller and more delicate than the type, but not otherwise distinct.

6. S. SPINESCENS Kützing, 1849, p. 418; 1854, Pl. LXXV, fig. 2; *Cladophora arcta* var. *centralis* P. B.-A., No. 721. Filaments about 80 $\mu$ below, 100 $\mu$ at tip; cells ½-1 diam. long below, 2 diam. long at tip; normal erect, somewhat obtuse branches abundant; also patent and acute branches, either short and spine-like, or long, hooked, revolute and circinate, uniting the filaments into branching rope-like tufts; descending rhizoidal branches less common. Fig. 126. Me. to Mass.; Alaska.
*Northern Europe.*

Often confused with *S. arcta*, which in its older stages is much matted; but in that species the filaments are united by the descending rhizoidal branches only; in *S. spinescens* chiefly by the hooked branches.

7. S. **coalita** (Rupr.) nov. comb.; *Cladophora coalita* P. B.-A., No. 819; *C. scopaeformis* Harvey, 1858, p. 75; P. B.-A., No. 922. Fronds at first loosely tufted, but soon forming dense, rope-like branching tufts, up to 30 cm. long; at first bright, later dull or yellowish-green; filaments 100-250 $\mu$ diam. in the terminal cell; branching dichotomous below, irregularly alternate above; all branches of this class erect, with blunt or truncate ends; also present, except in very young plants, abundant patent, tapering, very acute, hooked or circinate branches, by which all the older parts are densely matted together; cells 1/3-1 diam. long in the lower part of older plants, 2-3 diam. in younger plants, and even 6-10 diam. in the active terminal cell. Alaska to Cal. *Kamtschatka.*

The hooked branches distinguish this species from all others except *S. spinescens*, which is a smaller plant, with filaments about half the size of those in *S. coalita*. In the review of this group in Setchell and Gardner, 1903, p. 227, *Cladophora coalita* and *C. scopaeformis* were considered distinct species, but on looking over material from various points, and collected at various seasons, it seems impossible to keep them separate. *C. polaris* Harvey would seem to be the very young plant, with normal erect branches only, and with texture delicate. When the plant has nearly reached its full growth, it is *C. scopaeformis*, with long, green, actively dividing terminal cell to each normal branch; in the lower part of the filaments the cells are considerably shorter, and the walls cartilaginous; hooked branches are plentiful. At a still later stage the terminal cells have ceased to grow at the tip as fast as new cells have been cut off below; they are but little distinct from the other cells, either in length or texture. The division of the lower cells has gone on until most of them are shorter than their breadth; hooked branches have been developed until the greater part of the plant is now shaggy with them. The plant is now typical *Conferva coalita* of Ruprecht. *C. cartilaginea* Ruprecht very likely should be here included; but the description, 1856, p. 404, is hardly sufficient, and no authentic specimens are accessible. The specimens from Monterey, referred to *Cladophora cartilaginea*, Setchell and Gardner, 1903, prove to belong elsewhere.

*Spongomorpha rhizophora* Kützing, 1849, p. 418; 1855a, p. 16, Pl. LXXVI, fig. 2, is a doubtful species.

4. CLADOPHOROPSIS Börgesen, 1905, p. 288.

Frond filamentous, without distinct axis; basal filaments prostrate, attached by multicellular holdfasts; erect filaments with more or less abundant branching, with apical growth; a branch issuing directly under a cross wall, no wall being formed in the branch until the latter has attained a considerable length, and then normally not at the base of the branch; branches occasionally arising by aplanospore-like bodies formed in the cell, and pushing out through the cell wall; cells multinucleate, with net-shape chromatophore and many pyrenoids; reproduction unknown.

This genus is practically intermediate between *Cladophora* and *Siphonocladus*, showing the close relationship of the Cladophoraceae and the Valoniaceae. It has the habit of a *Cladophora* of the subgenus *Aegagropila*, but the branches have normally no partition at the base. In this latter respect it agrees with *Siphonocladus*, but the frond does not originate in a single clavate cell. The secondary branching reminds one of *Valonia*. We have only one species.

C. MEMBRANACEUS (Ag.) Börgesen, 1905, p. 288, figs. 8-13; *Cladophora membranacea* Harvey 1858, p. 73; *Siphonocladus membranaceus* Vickers, 1908, p.20, Pl. XVII; P. B.-A., No. 225. Fronds densely matted, up to 10 cm. high, the holdfasts of the prostrate filaments large and well developed; erect filaments about 180 $\mu$ diam., with branches at first alternate, later secund; partitions formed at irregular but usually long intervals, the terminal cell usually many diam. long; branches often adhering by tenacula similar to the basal holdfasts, but shorter; branches arising from aplanospore-like formation not uncommon. Fig. 129 Fla., W. I.

6. PITHOPHORA Wittrock, 1877, p. 48.

Fronds filamentous, monosiphonous, branching, branches issuing from below the top of the cells; cells cylindrical or swollen, multinucleate, with net-like chromatophore and many pyrenoids; asexual reproduction by akinetes, terminal or intercalary in the filaments, formed by the division of a vegetative cell, the upper half forming the akinete, the lower half remaining usually sterile; the germinating akinete dividing into two parts, of which one develops a short rhizoid, the other the initial cauloid filament of the future plant.

A genus of chiefly tropical and subtropical fresh water plants, closely allied to *Cladophora*, but the reproduction by akinetes appears to take the place of the reproduction by zoospores and gametes. Sterile plants are practically indistinguishable from *Cladophora*, but a fertile frond of *Pithophora* is unmistakable for anything else. Specific distinction, however, is not always easy. The species being naturally tropical, are often found in greenhouses where tropical plants are cultivated.

KEY TO THE SPECIES OF PITHOPHORA.

| | |
|---|---|
| 1. Intercalary akinetes all of about the same shape. | 2. |
| 1. Intercalary akinetes varying in the same plant; cylindrical, cask-shaped, obovoid or irregular. | 4. |
| 2. Main filament seldom under 150 μ diam. | 1. *P. aequalis.* |
| 2. Main filament less than 100 μ diam. | 3. |
| 3. Special helicoidal cells frequent. | 3. *P. Cleveana.* |
| 3. Special helicoidal cells wanting or very rare. | 2. *P. oedogonia.* |
| 4. Main filaments about 165 μ diam. | 5. *P. Roettleri.* |
| 4. Main filaments seldom reaching 100 μ diam. | 4. *P. varia.* |

1. P. AEQUALIS var. FLORIDENSIS Wolle, 1887, p. 131, Pl. CXIV, figs. 1-5. Main filaments in fertile plant 150-175 μ diam., with a few elongate branches, and many short branches; cells more or less swollen; akinetes solitary or rarely two together, intercalary in the main filaments or the long branches, rarely terminal; intercalary akinetes cask-shaped, with somewhat rounded top, about 215×120 μ; terminal akinetes cask-shaped, conical or sometimes rounded above, about 270×90 μ. Fla.

The type is found in So. America, and has main filaments seldom exceeding 100 μ diam., and akinetes slightly larger than in the variety.

2. P. OEDOGONIA (Mont.) Wittrock, 1877, p. 55, Pl. VI, figs. 1-6; including var. *vaucherioides* Wolle, 1887, p. 130, Pl. CXIII, figs. 1-7. Main filaments about 70 μ diam., branches of three orders scattered or opposite; branches occasionally issuing from the short cell below the akinete; akinetes solitary, rarely in twos, intercalary or terminal; intercalary akinetes cask-shaped, about 230 × 115 μ; terminal akinetes cask-shaped, above shortly acuminate, with rounded apex, about 215×95 μ.* Fig. 113. Pa., N. J., Neb. *So. America.*

**P. affinis* Nordstedt, 1878, p. 19; Saunders, 1894, p. 66, is reported from Neb., but no specimens have been seen. It was described from

3. P. CLEVEANA Wittrock, 1877, p. 58, Pl. II, figs. 13-15; Pl. IV, figs. 12-18; Pl. V, figs. 1-8. Main filaments about 75 $\mu$ diam., branches usually of the first order only, occasionally with a few short, scattered or opposite branches of the second order; special helicoid cells frequent; akinetes intercalary or terminal, solitary, rarely in twos; intercalary akinetes cask-shaped, 200-260 $\times$ 100-160 $\mu$, or subcylindrical, about 165 $\times$ 70 $\mu$; terminal akinetes cask-shaped with shortly acuminate rounded apex, 175-240 $\times$ 90-105 $\mu$. Fla., St. Thomas, Barbados.

4. P. VARIA Wille, P. B.-A., No. 983; *P. Kewensis* Tilden, Amer. Algae, No. 39. Filaments 75-105 $\mu$, primary and secondary branches about the same; terminal cells 43-70 $\mu$, rarely ending in helicoids; akinetes 1-3-seriate, with wall, especially end wall, quite thick, terminal and intercalary, arising in main stem or in branches of any order; terminal akinetes ovoid, with pointed tip, 150-210 $\times$ 64-69 $\mu$; intercalary 70-240 $\times$ 60-112 $\mu$; ovoid, cylindrical or irregular. Ill., Mich., Minn.

The only species of *Pithophora* native in colder regions. Nearest related to *P. Cleveana* Wittr., but differing in several characters. The akinetes occur even in the shortest branches, some branches consisting of two akinetes and nothing else. The form of the akinetes differs much in the same branch, and series of 2 or 3 are found including every possible combination of cylindrical, ovoid and irregular forms. *P. Kewensis* Tilden, No. 39, is identical with *P. varia; P. Kewensis* Wolle, 1887, p. 131, is founded on sterile plants, and cannot be considered reliable.

5. P. ROETTLERI (Roth) Wittrock, 1877, p. 66, Pl. I, figs. 12-20; Pl. V, figs. 11 and 12; *Cladophora Engelmanni* Kützing, 1849, p. 411. Main filaments about 165 $\mu$ diam., branching of three orders; branches of the first order in whorls of three or more; of second and third orders scattered or opposite; akinetes solitary, rarely in twos, intercalary or terminal; in the main filaments of irregular and varying shape, about 210 $\times$ 190 $\mu$; in the branches cask-shaped, about 260 $\times$ 150 $\mu$, or cylindrical, about 140 $\times$ 80 $\mu$; terminal akinetes obovoid with truncate base, about 210 $\times$ 150 $\mu$, or more rarely subconical with rounded apex, about 250 $\times$ 90 $\mu$. Cuba, Ark., in warm springs.

*Asia, So. America.*

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Hawaiian specimens, and differs from *P. oedogonia* by less compound branching, no branches from cells below akinetes, and akinetes varying much in size, but proportionally stouter than in *P. oedogonia*.

7. ANADYOMENE Lamouroux, 1816, p. 365.

Frond membranaceous, stipitate, membrane consisting of cells of two shapes, the larger, elongate cells forming a branching framework, radiating from the base and palmately divided; smaller roundish or ovoid cells issuing from the framework and filling its intervals, forming a continuous membrane; in some species the membrane is of two layers of these smaller cells. Zoospores formed in large numbers in the smaller cells, escaping through an opening. Marine.

The branching is beautifully symmetrical in the fronds of this genus, showing plainly under a pocket lens, or even to the naked eye. We have two species, one found throughout the warmer Atlantic, the other recorded once only, at some point, not definitely known, in the Gulf of Mexico.

KEY TO THE SPECIES OF ANADYOMENE.

1. Ribs of a single series of cells, each cell bearing above normally three or more similar cells, palmately arranged.
   1. *A. stellata.*

1. Ribs composed of several contiguous series of cells, branching only at considerable intervals. 2. *A. Menziesii.*

1. A. STELLATA (Wulfen) Agardh, 1822, p. 400; Vickers, 1908, p. 21, Pl. XXI; P. B.-A., No. 169; *A. flabellata* Harvey, 1858, p. 49, Pl. XLIV.A. Fronds often tufted, up to 10 cm. diam., usually ovate or reniform in outline, in older plants often much lobed; of a single thickness of cells; the stipe produced into palmately arranged clavate cells, forming similarly dividing series throughout the frond; interspaces filled with smaller oblong cells, issuing at right angles to the ribs, and forming a continuous membrane. Fig. 125. Fla., W. I.

*Mediterranean, So. America.*

J. G. Agardh, 1886, p. 125, mentions two forms; f. *normalis* and f. *luxurians*, the former with slenderer, longer, clavate or cylindrical rib-cells; the latter with stouter, shorter, ovoid cells; but he considers the latter form merely a luxuriant state of the former.

2. A. MENZIESII Harvey, 1858, p. 50; *Grayemma Menziesii* J. E. Gray, 1866, p. 51, Pl. XLIV, figs. 1 and 2. Frond up to 25 cm. diam., margin lobed, the stout ribs terminating in the lobes; rib formed of a bundle of parallel short-jointed filaments, the marginal ones giving out radiating branches of smaller cells, which form the membrane between the ribs.

Dredged in 40 meters in the Gulf of Mexico, in 1802, by Archibald Menzies; not since recorded.

### 8. MICRODICTYON Decaisne, 1839, p. 115.

Frond a sessile, membranaceous net-work, formed of monosiphonous filaments, densely branching in one plane in a radiate manner, the tip of one branch attaching itself to another branch by a terminal thickening; irregular, angular open spaces between the cells. Asexual (?) reproduction by zoospores, formed in any cell. Marine.

KEY TO THE SPECIES OF MICRODICTYON.

| | |
|---|---|
| 1. Cells rarely equalling 200 $\mu$ diam. | 1. *M. Agardhianum.* |
| 1. Cells up to 500 $\mu$ diam. | 2. *M. crassum.* |

1. M. AGARDHIANUM Decaisne, 1839, p. 115; *M. umbilicatum* Hauck, 1885, p. 467, fig. 203. Frond delicately membranaceous, filaments 50-200 $\mu$ diam., main veins rather distinct, radiate, branches patent; cells usually 2-4 diam. long. Fig. 132. Guadeloupe Island, Cal. *Europe.*

Our plant seems to agree with the common form of the Mediterranean, which is often known as *M. umbilicatum;* but there is a question whether the European plant is the same as *Conferva umbilicata* Velley, from the Hawaiian Islands; Decaisne's specific name is here used as the first one fairly certain.

2. M. CRASSUM J. G. Agardh, 1894, p. 107. Rather coarse in texture, filaments up to 500 $\mu$ diam.; cells seldom longer than broad, somewhat moniliform; branches of different orders little distinct in size or position. Bahamas.

A much coarser plant than our other species.

### 9. CYSTODICTYON Gray, 1866, p. 72.

Frond a perforated membrane with a framework of radiating, monosiphonous, articulate filaments, attached as in *Microdictyon;* the intervals being partly filled by smaller cells, with open central spaces; reproduction unknown. Marine.

In this genus there is the same network of radiate filaments as in *Microdictyon;* but there are also many short, one or few celled branches, issuing from the filaments irregularly, and attaching by thickened tips.

C. PAVONIUM J. G. Agardh, 1894, p. 109; P. B.-A., No. 666. Frond up to 3 cm. diam.; main filaments radiating from centers in various parts of the frond, stout, tapering, openings rounded, of various sizes. Fig. 127. Fla.

### 10. BOODLEA Murray, 1890, p. 243.

Frond as in *Cladophora*, but the branches attaching themselves one to another by the thickened tips, forming a more or less spongy frond.

From *Cladophora*, *Boodlea* is distinguished by the adherent tips of the branches, which, however, do not amount to a distinct organ as in *Struvea*; from *Microdictyon* it is distinguished by branching in all directions.

B. COMPOSITA (Harv. and Hook.) Brand, 1904, p. 187, Pl. VI, figs. 28-35; *Cladophora composita* P. B.-A., No. 722. Forming spongy, pale green tufts; filaments soft, pellucid, dichotomous below, above with opposite or whorled branches, all at wide angles; cells 2-5 diam. long; 200-225 $\mu$ diam. below, about 120 $\mu$ in the ramuli and there not much longer than broad. Fig. 128. British Columbia, Cal.

*Hawaiian and other Pacific Islands.*

This species occurs in dense masses in the litoral zone; the cells are much swollen, either ovoid or pyriform, the cell wall thin and delicate. The ramuli are usually opposite, but often whorled, and the habit is much like one of the branching Valonias.

### 11. DICTYOSPHAERIA Decaisne, 1842, p. 32.

Frond attached by rhizoids, rounded, solid or hollow, consisting of a cellular mass, or of a single layer of closely set, polygonal cells, attached to each other by short tenacula; frond increasing in size by the division of the cells of the single layer, or by externally giving off dense branches, forming an outer layer, the older layer persistent or perishing; reproduction unknown.

D. FAVULOSA (Ag.) Decaisne, 1842, p. 32; Harvey, 1858, p. 50, Pl. XLIV.B.; Vickers, 1908, p. 21, Pl. XXII; P. B.-A., No. 124. Frond always hollow, hemispherical or oblong in shape, unless broken by external causes; cells 5-6-angled, up to 2 mm. diam. Fig. 137. Fla., W. I., Mexico.

*Indian and Pacific Oceans.*

The roundish, light green, berry-like fronds, from 2 to 10 cm. diam., grow attached to corals and rocks, and are not likely to be mistaken for anything else.

### 12. HORMISCIA Fries, 1835, p. 327.

Filaments simple, attached at the base by growths from within the cell, or from the cell wall; cells multinucleate, all above the base similar, capable of division and of producing zoospores; chromatophore covering the cell wall, entire or net-like, with several pyrenoids; asexual reproduction by zoospores, many in a cell, obovoid, extending into a long projection below, and with 4 cilia above; also by akinetes formed by the breaking up of the filaments into individual cells, with thick wall, either producing new filaments or zoospores; sexual reproduction by biciliate gametes. Marine.

For discussion of the question of the claims of the generic names *Hormiscia* and *Urospora*, see Hazen, 1902, p. 147.

KEY TO THE SPECIES OF HORMISCIA.

1. Filaments distinctly clavate. 2.
1. Filaments nearly cylindrical. 4.
  2. Cells, except at extreme base, always wider than long. 4. *H. crassa.*
  2. Cells never shorter than width. 3.
3. Greatest diameter 135 μ. 5. *H. incrassata.*
3. Greatest diameter 500 μ. 2. *H. Wormskjoldii.*
  4. Filaments cylindrical; fertile cells not swollen. 3. *H. Hartzii.*
  4. Sterile filaments cylindrical or moniliform; fertile cells distinctly swollen. 5.
5. Filaments 30-60 μ diam., firm. 1. *H. penicilliformis.*
5. Filaments 50-170 μ diam., very soft and lubricous. 6. *H. collabens.*

1. H. PENICILLIFORMIS (Roth) Fries, 1835, p. 327; *Conferva Youngana* Harvey, 1846-51, Pl. CCCXXVIII; *Hormotrichum speciosum* Harvey, 1858, p. 90; *Ulothrix isogona* Farlow, 1881, p. 45; P. B.-A., No. 18. Filaments deep green, attached by outgrowths from within the lower cells, 30-60 μ diam., cells ⅓-2 diam. long, usually ¾-1½; vegetative cells cylindrical, fertile cells more or less swollen; chromatophore dense, nearly uniform. Fig. 133. Greenland to N. J.; Alaska to Cal. *Europe.*

A common species of northern regions on both sides of the continent, growing on rocks and timber in exposed places, often in company with *Bangia fusco-purpurea*, and most abundant in spring and summer.

2. H. WORMSKJOLDII (Mert.) Fries, 1835, p. 328; *Hormotrichum* (?) *Wormskjoldii* Harvey, 1858, p. 91; *Urospora Wormskjoldii* Rosenvinge, 1893, p. 920, fig. 36; P. B.-A., No. 915. Filaments attached by fibrils proceeding from the cell wall, 30-60 μ diam. at the base, increasing in size upward, even to 500 μ; lower cells cylindrical, 3-10 diam. long, upper cells shorter, fertile cells swollen, the largest nearly globular; chromatophore an open network. Greenland; Alaska to Wash.

A northern species, distinguished by the great difference in size between the base and summit of filament; the lower cells cylindrical, several times longer than broad; the upper cells ovoid or globular.

3. H. **Hartzii** (Rosenv.) nov. comb.; *Urospora Hartzii* Rosenvinge, 1893, p. 922, fig. 38. Filaments 75-90 μ thick, of nearly uniform diam., cells ½-3 diam. long, usually 1-2, cylindrical or very slightly swollen, fertile similar to vegetative; cell wall thin; chromatophore an open network. Greenland.

This species has only been found unattached; the manner of attachment, if known, would indicate whether it was allied in this respect with *H. penicilliformis* or with *H. Wormskjoldii*. In the uniform diameter of the filaments it agrees with the former, but has larger and usually longer cells, with thinner walls; in the arrangement of the chromatophore it agrees with the latter.

4. H. **crassa** (Rosenv.) nov. comb.; *Urospora crassa* Rosenvinge, 1898, p. 106, fig. 23. Filaments tapering to the base and somewhat to the apex; lower cells up to 70 μ, middle part 120-150, summit 105 μ diam.; cells in smaller portion ½ diam. long, nearly cylindrical; in larger portion ⅓-¼ diam. long, swollen; cell wall thick, chromatophore a network with relatively small openings. Greenland.

An imperfectly known species, neither the base of the filament nor the fertile cells having been observed; its best character would seem to be the short and stout cells.

5. H. **incrassata** (Kjellm.) nov. comb.; *Urospora incrassata* Kjellman, 1897a, p. 7, figs. 6-13; P. B.-A., No. 1125. Filaments attached by fibrils from the cell wall at the base, about 45 μ diam. at the base, increasing to 135 μ, somewhat diminishing in the few cells at the apex; lower cells cylindrical, 1-4 diam. long; upper cells 1-1½ diam. long, swollen; cell wall rather thin, chromatophore an open network. Alaska to Cal. *Europe.*

Nearly related to *H. Wormskjoldii* and *H. crassa*; the former has a greater difference in size between base and apex, and both have thicker cell wall and shorter cells.

6. H. COLLABENS (Ag.) Rabenhorst, 1868, p. 364; *Conferva collabens* Harvey, 1846-51, Pl. CCCXXVII; *Ulothrix collabens* Farlow, 1881, p. 45; P. B.-A., No. 970. Filaments very soft and lubricous, bright green, attached by growths from within the lower cells, cylindrical or increasing slightly upwards, varying much in diameter, 50-170 μ; cells 1-3 diam. long, usually

somewhat swollen, fertile much swollen; cell wall rather thin, chromatophore a rather close network. Mass. *Europe.*

The soft, lubricous substance is characteristic of this species, also the great variety in diameter of filaments growing in the same tuft. It is found on exposed rocky shores, in the lower litoral region, in very early spring.

## Family 2. GOMONTIACEAE.

Fronds consisting of creeping, branched filaments; cells multinucleate; asexual reproduction by biciliate zoospores or by aplanospores, both produced in sporangia formed on the upper surface of the horizontal layer, and ultimately detached from the same. Only one genus.

GOMONTIA Bornet and Flahault, 1888, p. 163.

Characters of the family.

KEY TO THE SPECIES OF GOMONTIA.

1. In marine shells; filaments 4-8 $\mu$ diam. 1. *G. polyrhiza.*
1. In fresh-water shells; filaments 12-50 $\mu$ diam. 2. *G. Holdenii.*

1. G. POLYRHIZA (Lagerh.) Bornet and Flahault, 1888, p. 164; 1889, p. CLVIII, Pl. VI, VII; P. B.-A., No. 315. Filaments 4-8 $\mu$ diam.; sporangia 30-40 $\mu$ diam.; zoospores of two sorts, one $10\text{-}12 \times 5\text{-}6$ $\mu$, the other about $5 \times 3.5$ $\mu$; development not known; aplanospores 4 $\mu$ diam. Fig. 135.

Abundant everywhere in dead shells on the shore; the filaments penetrating the substance of the shell, branching much and irregularly; sometimes forming a dense network for a considerable distance. It seldom occurs quite pure, but is usually in company with *Mastigocoleus testarum* Lagerh. and *Hyella caespitosa* B. and Fl. The three species show as stains on the surface of the shell, each having its own special color; the *Gomontia*, grass-green; the *Mastigocoleus* bluish- or violet-gray; the *Hyella* grayish- or yellowish-green. The latter, however, seldom occurs in sufficient quantity or purity to give its own color to the shell. In studying these species the calcareous matter must be dissolved away; Perenyi's fluid seems to be the best agent.

*G. polyrhiza* probably occurs all along both coasts; besides inhabiting dead shells, it is found on barnacles, and on the *Spirorbis* shells attached to Fuci, etc.

2. G. HOLDENII Collins, 1897, p. 95, Pl. IV.B., figs. 1-3; P. B.-A., No. 316. Filaments 12-50 $\mu$ diam., cells irregular in shape, oval, cylindrical or polygonal, terminal cell cylindrical or tapering; sporangia ovoid with elongate base, $100 \times 30\ \mu$. In *Unio* shells, in fresh water. Conn.

The large irregular cells distinguish this from *G. polyrhiza.*

## Family 3. VALONIACEAE.

Frond originating in a vesicular or clavate cell of limited growth, in all but the lowest forms branching or dividing into many cells, which may be irregularly arranged, or may form symmetrical, sometimes netlike fronds. Intercalary cell division by ordinary wall formation is not common; new cells arise generally by an outgrowth from the parent in a way that leaves some doubt as to whether the new cell should not be considered as a new individual, or else by the closing in of annular constrictions of the frond. All marine, chiefly plants of warmer waters.

Oltmanns, 1904, p. 255, removes from this family the genera *Siphonocladus*, *Chamaedoris* and *Struvea*, to form the family Siphonocladiaceae. The main distinction seems to be the presence of a distinct axis in the latter. If we follow Börgesen, 1905, p. 288, and remove from *Siphonocladus S. membranaceus* and its allies, this genus and the remaining genera of the family agree in the presence of an original upright cell of limited growth, and in the absence or rarity of intercalary division of the cells by cross walls; there would seem to be no need of dividing the family.

### KEY TO THE GENERA OF VALONIACEAE.

1. Frond always unicellular. — 1. HALICYSTIS.
1. Mature frond pluricellular. — 2.
  2. Original cell constituting a stipe different in character from the rest of the frond. — 3.
  2. All cells similar to the original. — 4.
3. Stipe crowned by a network. — 6. STRUVEA.
3. Stipe crowned by a dense tuft of filaments. — 5. CHAMAEDORIS.
  4. Daughter cells arising from the surface of the mother cells. — 2. VALONIA.
  4. Entire contents of cell dividing into numerous smaller cells, each of which may develop like the mother cell. — 5.
5. Erect or tufted, not calcified. — 3. SIPHONOCLADUS.
5. Forming an adherent disk; somewhat calcified. — 4. PETROSIPHON.

### 1. HALICYSTIS Areschoug, 1850, p. 447.

Frond unicellular, multinucleate, saccate, with narrow basal portion; chromatophores minute disks without pyrenoid. Asexual reproduction by biciliate zoospores without stigma, escaping through one or more openings; similar but smaller zoogametes (?) formed in separate individuals; after the emission of the spores the openings close and several new generations of spores can be similarly produced.

Though this genus was proposed for the following species as long ago as 1850, its validity has been questioned, but studies by Kuckuck, 1907, remove all doubt.

H. OVALIS (Lyng.) Areschoug, 1850, p. 447; Kuckuck, 1907, p. 139, Pl. III. Fronds solitary or gregarious, obovate-ovoid, ½-1 cm. high, about half as wide; membrane tough, 10-12 $\mu$ thick; basal prolongation penetrating the substratum; zoospores 12-14×7-8 $\mu$; gametes (?) 7-8×2-3 $\mu$. Fig. 130. Vancouver Island to Monterey, Cal. *Northern Europe.*

This species has always been found growing on crusts of *Lithothamnion* or similar calcareous algae, the radical portion boring deeply into the substratum, apparently like *Gomontia*.

### 2. VALONIA Ginnani, 1757, p. 38.

Fronds not calcified, at first a single ovoid or clavate multinucleate cell, producing more or less numerous cells similar in form to itself; this process being repeated more or less frequently in different species; unicellular rhizoids being similarly produced; chromatophore forming a network with many pyrenoids; asexual reproduction by 2- or 4-ciliate zoospores, escaping through numerous openings, and developing at once into plants similar to the parent.

As long as *V. ovalis* was included in this genus, it was difficult to define the latter clearly; by the removal of that species as *Halicystis ovalis*, the matter is much simplified.

KEY TO THE SPECIES OF VALONIA.

1. Frond bullate, unbranched. 1. *V. ventricosa.*
1. Frond more or less abundantly branched. 2.
  2. Cells obovate-clavate, sparingly and irregularly branched. 2. *V. utricularis.*
  2. Cells subcylindrical. 3.
3. Branches irregularly placed. 3. *V. aegagropila.*
3. Branches in regular whorls. 4.
  4. Whorls frequent and dense; cells rather short. 4. *V. verticillata.*
  4. Whorls distant and loose, cells long. 5. *V. confervoides.*

1. V. VENTRICOSA J. G. Agardh, 1886, p. 96; Murray, 1893, Pl. XIII, figs. 6-10; Vickers 1908, p. 21, Pl. XXIII.A. Frond solitary, saccate, spherical to pyriform, usually 2-3, rarely 5 cm. diam.; secondary cells formed chiefly at the base for purposes of attachment; membrane smooth, translucent, showing the light green contents. W. I.

Practically unmistakable for any other species; *Halicystis ovalis*, the only one that it resembles, being smaller and an inhabitant of quite different regions. The fronds are usually about the size of a large cherry, but Murray has dredged specimens "as large as a hen's egg."

2. V. UTRICULARIS Agardh, 1822, p. 431; Kützing, 1856, Pl. LXXXVI, fig. 2b-e; Wittr. and Nordst., Alg. Exsicc., No. 953. Cells stout, cylindric-clavate, with similar proliferations; lower parts of frond decumbent, or creeping among other algae, then erect, up to 5 cm. high, often forming dense tufts; membrane dark green, shining; zoospores biciliate. Fig. 138. Bermuda, Bahama. *Europe.*

Growing from the litoral zone to a depth of 2 m.; in the former station the filaments are shorter and stouter; in the latter longer and more slender.

3. V. AEGAGROPILA Agardh, 1822, p. 429; Kützing, 1856, Pl. LXXXVII, fig. 1; P. B.-A., No. 772. Fronds much and irregularly branched, cells subcylindrical, rather short, 2-3 mm. diam., forming a dense, globular tuft; membrane rather dull. W. I. *Mediterranean, Indian, Pacific Oceans.*

Nearly allied to *V. utricularis*, but with more slender, less clavate cells, and forming denser masses, soon freed from the substratum and floating in shallow water.

4. V. VERTICILLATA Kützing, 1849, p. 508; 1856, p. 30, Pl. LXXXVIII; Vickers, 1908, p. 21, Pl. XXIII.B; P. B.-A., No. 1533. Cells cylindrical, straight, 2-3 mm. diam., producing whorls of similar cells below the obtuse apex; branching repeated, forming tufts about 5 cm. high; membrane very delicate and translucent. W. I.

The regular and frequent whorled branches distinguish this from all our other species; dried specimens adhere to paper more firmly than in other species.

5. V. CONFERVOIDES Harvey, Alg. Ceylon Exsicc., No. 73; Wittr. and Nordst., Alg. Exsicc., No. 349. Fronds decumbent at first, then ascending, cylindrical, 2-3 mm. diam., simple below, above branching sparingly, usually 3-4 branches in a

whorl, branches patent, more or less incurved, membrane firm, color dull green, forming dense tufts, many cm. diam. Bermuda. *Indian and Pacific Oceans.*

Like *V. verticillata* this species has whorled branches, but the whorls are fewer branched and less frequent; the cells are many times longer.

3. SIPHONOCLADUS Schmitz, 1878, p. 17.

Frond originating in a simple clavate cell, attached by multicellular rhizoids at the base, of definite growth; ultimately becoming multicellular by the transformation of the contents into cyst-like cells, uniting sub-parenchymatously, then each pushing through the mother cell wall, assuming a shape like the mother cell and developing in the same way as the latter. Asexual reproduction by escape and growth of the cysts; reproduction also by zoospores formed in large numbers in the clavate cells; probably asexual. Ordinary cell division by cross walls not certainly observed.

The primary cell in *Valonia* appears to bear branches with a partition at the base of each; in *Siphonocladus* a multicellular filament appears to take the place of the primary cell, each cell of the filament producing a branch without partition at the base.

KEY TO THE SPECIES OF SIPHONOCLADUS.

1. Primary cell long, erect; substance soft. 1. *S. tropicus.*
1. Primary cell short; substance firm and crisp. 2. *S. rigidus.*

1. S. TROPICUS (Crouan) J. G. Agardh, 1886, p. 105; Howe, 1905, p. 245, Pl. XIII, fig. 2; Vickers, 1908, p. 20, Pl. XVIII. Primary cell up to 4 cm. long, 1 cm. wide, with annular constrictions near the base; branches similar, also with constrictions near base, often longer than the primary cell; cells of third generation similar but generally shorter; zoospores many in a cell which has reached its full growth, escaping by small perforations in the walls. Fla., W. I.

2. S. RIGIDUS Howe, 1905, p. 244, Pl. XII, fig. 1; Pl. XIV; P. B.-A., No. 1489; *S. tropicus* P. B.-A., No. 1031. Frond a more or less dense tuft of pale green, crisp filaments, main axis hardly distinguishable; branching sub-dichotomous, irregular, or secund; filaments 350-1100 μ diam., often united by short tenacula. Fig. 139. Bahama.

Howe's description of this species was apparently written without knowledge of Börgesen, 1905, which was published about the same time; in the light of Börgesen's studies of *S.*

*tropicus*, Howe's figures of *S. rigidus* would seem to be interpreted best as representing a development by "cysts," much as in the former species. There is little doubt of the distinctness from *S. tropicus*, but the relations in this direction are certainly closer than those with *Cladophoropsis membranaceus*. It is at least probable that the lateral branches in Howe, Pl. XIV, fig. 2, correspond to the branches in Börgesen, fig. 4; and that the frond originates in a similar, somewhat clavate cell.

4. PETROSIPHON Howe, 1905, p. 248.

Filaments united to form a disk, somewhat calcified, firmly attached to the substratum, and piercing the same by rhizoids; disk monostromatic at the margin, polystromatic elsewhere, the center often of short, erect filaments; asexual reproduction by aplanospores.

P. ADHAERENS Howe, 1905, p. 248, Pl. XV. Disks light green, 2-6 cm. diam., orbicular or irregular, closely approximate; margin striate; up to 5 mm. thick at the center; horizontal filaments 300-850 $\mu$ diam., straight or geniculate, dichotomous; cells $\frac{1}{2}$-20 diam. long; rhizoids very abundant, penetrating the substratum; aplanospores varying in size and form. Bahamas.

In characters of filaments, etc., like *Siphonocladus*, but differing by the definite disk-shaped frond, and the incrustation; it is closely adherent to the rock on which it grows.

5. CHAMAEDORIS Montagne, 1842, p. 261

Frond erect, with firm, clavate stipe, attached by rhizoids at the base, and bearing a dense tuft of branching, articulate filaments at the tip; stipe monosiphonous, with closely set, annular constrictions, much calcified.

C. ANNULATA (Lamarck) Montagne, 1842, p. 261; Harvey, 1858, p. 43, Pl. XLII.B; Vickers, 1908, p. 22, Pl. XXIV; P. B.-A., No. 629. The only species; stipe up to 10 cm. high; head 2-3 cm. diam. Fig. 136. Fla., W. I.

*Africa, So. America, Indian Ocean.*

The mop-shaped fronds are not to be mistaken.

6. STRUVEA Sonder, 1845, p. 49.

Frond attached below by multicellular branched rhizoids; stipe simple or branched, monosiphonous, bearing one or more flabelliform, net-like expansions, consisting of articulate, pinnately branched filaments, the tips of the branches attaching themselves to other filaments to form the network. Reproduction unknown.

A genus of tropical algae, with beautifully symmetrical net-like fronds, in which the filaments apparently anastomose, but really are united by peculiar organs, "tenacula," formed on the tips of the cells when they come in contact with other cells of the fronds, or, in some species, of other fronds. The tenacula are short cylindrical prolongations of the cell wall, ending in dense short branches; reminding one somewhat of the shape of a sea-anemone. In the corresponding organs in *Microdictyon* the attaching surface has a somewhat crenulate margin, but does not develop branches. The primary cell of *Struvea* is at first clavate, later spindle-shaped, and appears to attain its full growth before the network is formed. There is some uncertainty as to how the "articulations" of the network arise, but it seems probable that it is by the deepening of the annular constrictions, not by true wall formation.

KEY TO THE SPECIES OF STRUVEA.

1. Stipe unbranched. 1. *S. anastomosans.*
1. Stipe branched. 2.
   2. Each branch of the stipe with a separate network. 3. *S. ramosa.*
   2. One network only. 2. *S. pulcherrima.*

1. S. ANASTOMOSANS (Harv.) Piccone, 1884, p. 20; *S. delicatula* Murray and Boodle, 1888, p. 281, Pl. XVI, figs. 6 and 8; Vickers, 1908, p. 20, Pl. XIX; *Cladophora anastomosans* Harvey, 1855, p. 565, name only; 1859, Pl. CI. Stipe smooth, simple, slender, crowned with a subpyramidal network, 3-5 cm. long; filaments repeatedly pinnate, pinnae and pinnules opposite, horizontally patent, more or less attached to each other. Fig. 134. Guadeloupe, Jamaica. *Australia, Canaries.*

This species shows a resemblance to the *Pellucida* section of *Cladophora;* the union of the branches is only partial, and varies much as to completeness.

Var. CARACASANA Grunow in Murray and Boodle, 1888, p. 281; Vickers, 1908, p. 20, Pl. XX. Frond regularly bipinnate; branches seldom united. Barbados. *So. America.*

2. S. PULCHERRIMA (J. E. Gray) Murray and Boodle, 1888, p. 281, Pl. XVI, fig. 4. Stipe smooth, three-parted, crowned with a single, cordate, three-ribbed network, 30×20 cm.; fila-

ments repeatedly pinnate, articulations of the pinnae 3-4 diam. long, of the pinnules 2 diam. Fla., Gulf of Mexico.

This species was dredged by Menzies early in the last century, and his single specimen remained undescribed until 1866, when it was taken by J. E. Gray, 1866, p. 70, as the type of the new genus *Phyllodictyon*. The original specimen, though over 30 cm. long, is evidently fragmentary; a single, smaller fragment, found by Mrs. G. A. Hall, at Jupiter Inlet, Florida, is the only record since Menzies. *S. pulcherrima* seems to be the rarest, as well as one of the most interesting of our green algae.

3. S. RAMOSA Dickie, 1874, p. 316; Murray and Boodle, 1888, p. 280, Pl. XVI, fig. 3. Stipe with a few annular constrictions, above oppositely branched, each branch ending in a sub-elliptical network, about $3 \times 1\frac{1}{2}$ cm.; filaments tripinnate, lower articulations 7-8 times their diam., upper 3-4 times. Bermuda.

## Family 4. DASYCLADACEAE.

Frond consisting of a long, inarticulate axillary cell, attached by rhizoids below, and of whorls of usually pluricellular, simple or branching ramuli of limited growth; in fertile ramuli are produced either gametes, or aplanospores which when freed produce gametes.

Marine plants of warm waters and general distribution.

### KEY TO THE GENERA OF DASYCLADACEAE.

1. Frond calcified. 2.
1. Frond not calcified. 6.
  2. Frond with slender stipe and with whorls of branches terminal or at considerable intervals. 3.
  2. Whorls of branches contiguous, concealing the axis. 5.
3. Spores contained in whorled branches, not calcified. 1. ACETABULARIA.
3. Spores contained in whorled branches, calcified. 4.
  4. Spores imbedded in a solid mass of lime, but membrane free from lime. 3. ACICULARIA.
  4. Spores free, membrane much incrusted. 2. CHALMASIA.
5. Stem branching, moniliform. 5. CYMOPOLIA.
5. Stem unbranched, surface continuous. 4. NEOMERIS.
  6. Sporangia terminal; whorls very closely set. 6. DASYCLADUS.
  6. Sporangia lateral, whorls rather distant. 7. BATOPHORA.

### 1. ACETABULARIA Lamouroux, 1816, p. 244.

Frond calcified, with perennial root and annual erect axis clothed with deciduous whorls of hairs, terminating in a cap-like whorl, with rays either free or joined; each ray bearing on its upper surface near the base a prominence, the prominences forming a ring "corona superior," with scars corresponding to deciduous tufts of hairs borne by them. A corresponding ring on the lower surface of the rays "corona inferior" is present in some species. Entire contents of the rays changing into globose or ovoid aplanospores with membrane free from lime; after a period of rest these aplanospores open by a cap, and give out zoogametes, which by conjugation form a zygote, by whose germination the plant is reproduced.

A genus of very delicate and beautiful plants, seldom over a few cm. high, living in shallow salt water in tropical and subtropical regions. The two following genera, *Chalmasia* and *Acicularia*, are practically of the same habit, but differ in spore characters.

KEY TO THE SPECIES OF ACETABULARIA.

| | |
|---|---|
| 1. Rays less than 20. | 2. |
| 1. Rays 20 or more. | 3. |
| 2. Corona superior not over 35 $\mu$ diam. | 5. *A. pusilla*. |
| 2. Corona superior 75 $\mu$ diam. or more. | 4. *A. polyphysoides*. |
| 3. Rays apiculate. | 1. *A. crenulata*. |
| 3. Rays not apiculate. | 4. |
| 4. Rays free or slightly coherent. | 3. *A. Farlowii*. |
| 4. Rays firmly united. | 2. *A. caliculus*. |

1. A. CRENULATA Lamouroux, 1816, p. 249; Harvey, 1858, p. 40, Pl. XLII.A.; Vickers, 1908, p. 29, Pl. XLVIII; P. B.-A., No. 125; *A. caraibica* Kützing, 1856, p. 33, Pl. XCIII; Vickers, 1908, p. 29, Pl. XLIX. Stipe up to 4 cm. high, bearing a terminal disk with crenulate margin, 6-15 mm. diam., and often several other disks at various points, or nodes showing the positions of former disks; rays (sporangia) 30-80, firmly united, ends arched, with a short apiculum at the middle; corona superior .15-.26 mm. diam., with two hair-scars on each ray; aplanospores 75-140 $\mu$ diam., 300-500 in a sporangium. Fig. 131. Fla., W. I.

A common and beautiful species, in general shape like a small and delicate mushroom. *A. caraibica* is kept distinct by Solms, 1895, but Howe, 1901, having made a careful study of the living plants of our American species, finds it impossible to distinguish the two.

2. A. CALICULUS Quoy and Gaimard, 1824, p. 621, Pl. XC, figs. 6 and 7; Solms, 1895, p. 25; *A. Suhrii* Solms, 1895, p.

25, Pl. I, figs. 9 and 13. Slender, stipe 1½-3 cm. high, with occasional spindle-shaped swellings; disk cup-shaped, 6-7 $\mu$ diam.; rays 25-30, not strongly united, the blunt margin with a broad, deep, squarish depression; corona superior about 90 $\mu$ diam., with 2 or 3, sometimes 4 hair-scars on each ray; aplanospores about 160 $\mu$ diam., about 80 in a sporangium; gametes developed before the release of the aplanospores from the sporangium. St. Thomas, Jamaica.

*Indian and South Pacific Oceans.*

In general appearance like a delicate *A. crenulata*, but with only one disk, different shape in the margin of the disk, usually more hair-scars than in *A. crenulata*, and with rays less firmly united.

3. A. FARLOWII Solms, 1895, p. 27, Pl. III, fig. 1; P. B.-A., No. 1032; *Acetabulum Farlowii* Howe, 1905a, p. 577. Stipe 1-2 cm. high; disk 4-7 mm. diam., nearly flat; rays 20-30, lightly coherent or free, slightly compressed towards the obtuse or truncate ends; corona superior .15 mm. diam., with two hair-scars on each ray; aplanospores 40-120 in a sporangium. Fla.

Distinguished from *A. crenulata* by the loosely attached or entirely free rays, and from *A. caliculus* by the flattish disk with obtuse rays; in mature plants the rays are often entangled, so that the regular form of the disk is lost.

4. A. POLYPHYSOIDES Crouan in Schramm and Mazé, 1866, p. 101; Solms, 1895, p. 29, Pl. IV, figs. 2 and 6; Vickers, 1908, p. 28, Pl. XLVII; *Acetabulum polyphysoides* Howe, 1909, p. 92, Pl. VI, figs. 16-20; Pl. VII, figs. 5-9. Stipe seldom over 1 cm. high, disk single, cup-shaped or nearly flat, 2-5 mm. diam.; rays 11-25, mostly 12-18, vesicular, from obovoid to subfusiform, obtuse and rounded at the end, loosely united by a thin calcification; corona superior 75-150 $\mu$ diam., a whorl of 5-13, usually 8 or 9, hair-scars on each ray; aplanospores 90-190 $\mu$ diam., 6-50 in a sporangium. W. I.

The few and swollen rays sufficiently distinguish this species from the preceding, apart from the characters of the hair-scars.

Forma **deltoidea** (Howe) nov. comb.; *Acetabulum polyphysoides deltoideum* Howe, 1909, p. 92, Pl. VI, fig. 21; Pl. VII, fig. 10. Rays usually 7, much inflated, inversely deltoid or obovoid-deltoid; hairs scars 6-8. Bahamas.

Very distinct in appearance by the few and broad rays, but there are intermediate forms between this and the typical form.

5. A. **pusilla** (Howe) nov. comb.; *Acetabulum pusillum*

Howe, 1909, p. 89, Pl. VI, figs. 13-15; Pl. VII, figs. 1-4. Stipe 1-3 mm. high, disk solitary, nearly flat, 1-2.5 mm. diam., rays 6-17, usually 11-15, obovoid-clavate to clavate-subfusiform, blunt or obtusely taper-pointed, easily separable; corona superior 22-35 $\mu$ diam., with 2, rarely 3 hair-scars; aplanospores 15-60 in a sporangium, 68-82 $\mu$ diam. W. I.

The smallest of our species, and quite lightly calcified.

2. CHALMASIA Solms, 1895, p. 32.

Disk terminal, composed of rays united only by the incrustation; corona inferior wanting; segments of the corona superior not touching laterally; aplanospores free, with thick, much calcified membrane. Only one species.

C. ANTILLANA Solms, 1895, p. 32, Pl. III, figs. 2, 3, 5. Disk funnel-shaped, 6 mm. diam., rays 25-32, covered with a thin, easily detachable incrustation, and not otherwise united, vesicular and inflated; aplanospores globular, chalk-white; hair-scars 2-3. Fig. 140.

In habit quite like a small *Acetabularia crenulata*, but sufficiently distinct in the spore characters. The only known specimens were dredged at some point, not definitely known, off the Florida coast.

3. ACICULARIA D'Archiac, 1843, p. 386.

Rays of the disk united, corona superior and corona inferior present; interior of the ray ultimately occupied by a calcareous mass enclosing uncalcified aplanospores.

The genus was founded by the paleontologist D'Archiac in 1843, on certain minute spicules found in the Eocene formation in France; two or three other fossil species have since been recognized, but only one living species is known.

A. SCHENCKII (Möb.) Solms, 1895, p. 33, Pl. III, figs. 4, 9, 11, 12, 14, 15. Stipe 1-3 cm. high, thin-walled, rather stout; disk 6 mm. diam., flat or nearly so, with crenulate margin; rays 30-50, fairly closely united, wedge-shaped; corona superior 13 mm. diam., with 2 hair-scars to each ray; aplanospores 100-200 in a ray, globose, 60-80 $\mu$ diam. From litoral to 30 m. depth. Bermuda, Martinique, Guadeloupe. *So. America.*

4. NEOMERIS Lamouroux, 1816, p. 241.

Frond cylindric-clavate, more or less strongly calcified, consisting of a simple, inarticulate axis, attached by lobed or branched holdfasts, and bearing thickly set, uniform whorls of 12-80 primary branches, each branch except those of the lower whorls bearing a terminal short-stiped sporangium, and two secondary branches, whose swollen tips constitute the surface of the frond, and which when young bear each a simple or branching hair; sporangium containing a single large spore, probably an aplanospore, with an operculum at the base; development unknown.

Rather insignificant appearing plants, the species much alike in habit, demanding dissection and microscopic examination for specific determination. Howe, 1909, gives full details of foreign as well as of American species.

KEY TO THE SPECIES OF NEOMERIS.

1. Branches of the second order subfusiform, hardly forming a cortex. 4. *N. Cokeri.*
1. Ends of the branches of the second order forming a cortex with distinct facets. 2.
   2. Sporangia laterally coherent by the calcareous coating. 3. *N. annulata.*
   2. Sporangia strongly calcified but mutually free. 3.
3. Plants 1-2 mm. thick, 15-20 times as long. 1. *N. dumetosa.*
3. Plants 1.5-2.5 mm. thick, 4-8 times as long. 2. *N. mucosa.*

1. N. DUMETOSA Lamouroux, 1816, p. 243, Pl. VII, fig. 8; Howe, 1909, p. 77, Pl. I, fig. 1; Pl. V, fig. 20; Pl. VI, figs. 1 and 2. Gregarious or scattered, subcylindrical, slender, 20-40 mm. high, 1-2 mm. thick, apex acute or acuminate; primary branches 500-700 $\mu$ long, 14-30 $\mu$ diam., 28-40 in a whorl, whorls 300-400, averaging 100 $\mu$ apart, more distant near the apex; secondary branches capitate, inflated at the tip to 100-185 $\mu$ diam., outwardly rounded, strongly calcified except on the outer surface; sporangia strongly calcified but mutually free, containing each an aplanospore 135-160 $\times$ 130-155 $\mu$. W. I.

*Europe.*

The original species of the genus, and the one to which all forms were first referred; not found in recent years in the West Indies, very likely narrowly limited in its localities, like some of the other species of the genus.

2. N. MUCOSA Howe, 1909, p. 84, Pl. I, fig. 5; Pl. V, figs. 1-14. Gregarious, mostly in clusters of 3-20; subcylindrical or fusiform, 8-20 mm. high, 1.5-2.5 mm. thick, apex acute or acuminate; primary branches 275-400 $\mu$ long, cylindrical or clavate, mostly 40-100 $\mu$ diam., 28-48 in a whorl, whorls 120-300, averaging 120 $\mu$ apart; secondary branches capitate, inflated at the tip to 100-220 $\mu$ diam., strongly calcified except at the end surface, which is mammiform, subconical or subrostrate, with very thin, mucilaginous wall; sporangia strongly calcified but

mutually free; aplanospores obovoid, 140-160×105-120 μ. Bahamas, Cuba.

A shorter and stouter plant than *N. dumetosa*, with very soft and gelatinous membranes.

3. N. ANNULATA Dickie, 1874, p. 198; Howe, 1909, p. 87, Pl. I, fig. 2; *N. Kelleri* Cramer, 1888, p. 3, Pl. I, fig. 2; Pl. II, figs. 1-12; Pl. III, figs. 1-2; 1890, p. 9, Pl. I, figs. 1-12; Pl. II, figs. 1-6; Pl. IV, figs. 15-24; Vickers, 1908, p. 28, Pl. XLVI; *N. dumetosa* P. B.-A., No. 668. Mostly densely gregarious, subcylindrical or fusiform-clavate, 5-25 mm. high, 1-2 mm. thick, apex subacute; primary branches 200-280 μ long, 11-20 μ median diam., 20-56 in a whorl, whorls 60-175, 115-250 μ apart; secondary branches capitate, inflated at the tip to 80-135 μ diam., outwardly usually rounded, rather firm-walled, strongly calcified except at the outer end, firmly coherent; sporangia strongly calcified and laterally coherent into nearly complete or more or less interrupted rings; aplanospores oblong-ovoid to oblong-ellipsoid, 115-175×46-80 μ. Fig. 143. Fla., W. I. *So. America, Indian and Pacific Oceans.*

The complete or somewhat broken rings of sporangia can generally be depended on to distinguish this species.

4. N. COKERI Howe, 1904, p. 97, Pl. VI, figs. 3-12; 1905, p. 580; 1909, p. 89, Pl. I, fig. 6. Solitary or somewhat gregarious, subcylindrical or clavate, 7-37 mm. high, 1.5-3 mm. diam., apex rounded, obtuse or subtruncate; primary branches 200-300 μ long, 30-40 μ diam., 12-56 in a whorl, whorls 60-175, about 100 μ apart; secondary branches somewhat calcified, scarcely adherent, subfusiform, curved or gibbous, 100-150 μ diam. near the middle, tapering to 22-34 μ at the truncate apex; terminating in a hair; hairs of two kinds, the first unicellular, clavate, curved or hooked, diam. about equal to that of the supporting cell, the second with a similar but narrower basal cell, bearing at its apex two slender, subcylindrical cells, each in its turn with 2-4 similar but smaller branches; the two forms of hairs in separate zones; sporangia strongly calcified, free or coherent in rows of 2-8; aplanospores obovoid or oblong-ellipsoid, 140-190×82-94 μ. Bahamas.

Distinguished by the fusiform secondary branches and the two types of hairs, in distinct zones on the same individual.

5. CYMOPOLIA Lamouroux, 1816, p. 292.

Frond branched, consisting of a series of bead-like calcified joints, connected by contracted, flexible uncalcified portions, in which the branching occurs; stem and branches terminated by tufts of branched, pluricellular hairs; at the uncalcified portions, whorls of sterile, undivided branches; in the calcified portions, whorls of branches each with a terminal sporangium, and branches enclosing and passing beyond it; the swollen ends forming the surface of the frond. Development of spores unknown.

C. BARBATA Lamouroux, 1816, p. 293; Harvey, 1858, p. 36, Pl. XLI.A.; P. B.-A., No. 28. Frond to 20 cm. long, varying much in density of branching; joints from depressed-spherical to cylindrical and several diameters long; usually 1-3 mm. diam.; 10-30 whorls of branches in a joint, 20-30 branches in a whorl; sporangia globose or short-pyriform, 160-200 $\mu$ diam. Fig. 146. Fla., W. I.

*C. rosarium* Lamouroux and *C. mexicana* J. G. Agardh represent extreme forms, the former with joints mostly globular, the latter with joints mostly cylindrical. A single plant will often have branches representing these extremes, which therefore should not have even varietal rank.

6. DASYCLADUS Agardh, 1827, p. 640.

Stem unbranched, cylindric-clavate, uncalcified, attached at the base by a lobed expansion, and bearing in the upper part whorls of about 12 ramuli each; ramuli repeatedly branching, each branch a distinct cell; gametangia spherical, terminal on the first cell of a ramulus and surrounded by its branches, producing biciliate gametes, by whose union is formed a zygote, germinating immediately.

D. CLAVAEFORMIS (Roth) Agardh, 1828, p. 16; Kützing, 1856, Pl. XCI, fig. 2; P. B.-A., No. 170. Fronds gregarious, 2-4 cm. high, about 5 mm. diam.; whorls of ramuli closely set; gametangia 400-550 $\mu$ diam. Fig. 142. Fla., W. I.
*Mediterranean.*

With the exception of a short basal portion, the whole of the axis is covered with whorls so closely set as to form an apparently solid mass, the individual whorls being quite indistinguishable. In drying the plant usually gives out a brownish-yellow fluid, staining the paper on which it is mounted.

7. BATOPHORA J. G. Agardh, 1854, p. 108.

Vegetative frond as in *Dasycladus;* sporangia chiefly lateral on the ramuli and their branches, producing aplanospores.

B. OERSTEDI J. G. Agardh, 1854, p. 108; P. B.-A., No. 1490; *Botryophora Conquerantii* Cramer, 1890, p. 6, Pl. IV, fig. 1; *B. occidentalis* P. B.-A., No. 667; *Coccocladus occidentalis* var.

*laxus* Howe, 1904, p. 95, Pl. VI, figs. 1 and 2. Fronds up to 10 cm. high, rather soft and flaccid, 10-13 mm. diam.; whorls distinct, not very close; sporangia ellipsoid to pyriform-subclavate, 500-1000 × 325-450 μ, lateral or occasionally terminal on branches of the first to the fourth orders; aplanospores ellipsoid, 50-70 μ diam., 1½ times as long, in a single layer on the inner surface of the sporangium. Fig. 145. Fla., W. I.

Var. OCCIDENTALIS (Harv.) Howe 1905a, p. 579; *Dasycladus occidentalis* Harvey, 1858, p. 38, Pl. XLI.B. Fronds shorter and smaller, whorls more closely set, ramuli less branched; sporangia spherical or nearly so; aplanospores more numerous, nearly filling the sporangium. With the type.

The form described as *B. Oerstedi* is a plant of quiet brackish waters; the var. *occidentalis* inhabits exposed shores, and quite resembles *Dasycladus;* like the latter, the plants stain paper yellow, while plants of the type do not.

## Family 5. SPHAEROPLEACEAE.

Frond an unattached, monosiphonous, unbranched filament, consisting of long, cylindrical, multinucleate cells, each with many minute, disk-shaped chromatophores arranged in distinct zones, and many pyrenoids; sexual reproduction by antheridia and oogonia, which may be formed in the same or in separate filaments; antheridia formed of vegetative cells, unchanged in shape and size, the contents becoming orange colored, and transformed into a large number of long-clavate or spindle-shaped, biciliate spermatozoids, escaping through numerous openings in the cell wall; oogonium from a vegetative cell, unchanged in shape or size, the contents transformed into numerous spherical, uninucleate oospores, fertilized by spermatozoids entering the cell by numerous openings; oospore after fertilization brick-red, with three colorless membranes, the outer membrane ample and with wavy folds; germinating oospore producing 1-8 biciliate zoospores, which on germination are much elongated, and ultimately form a filament like the normal, but with pointed ends; unfertilized oospores may sometimes germinate parthenogenetically.

A rather isolated family, represented by only one genus.

### SPHAEROPLEA Agardh, 1824, p. XXV.

Characters of the family.

S. ANNULINA (Roth) Agardh, 1824, p. 76; Wolle, 1887, p. 104, Pl. CXXIII, figs. 1-5; P. B.-A., No. 317. Filaments 27-72 μ diam., cells 8-20 diam. long; 20-30 zones of chromatophores in a cell; oospores usually in two longitudinal series, 11-26 μ diam., including membrane. Fresh water. Fig. 141. Minn., Cal. *Europe.*

A plant of shallow, easily dried pools; the oospores retaining vitality for years, and germinating when again moistened. Of wide distribution in isolated stations. Klebahn, 1899, divides *S. annulina* into two species, *S. crassisepta* (Heinrich) Klebahn, and *S. Braunii* Kützing; the former with filaments 27-35 μ diam., 500-1200 μ long, oospores 11-19 μ diam., including membrane, mostly 14 μ, dissepiments thick, often with conical projections; the latter with cells 42-65 × 250-1400 μ, oospores 13-26 μ, mostly 17-19 μ, dissepiments relatively thin and even. Whether there are two distinct species, or only two forms or varieties of *S. annulina*, is hardly certain; in the former case it would not seem that the name of *S. annulina* should be given up in favor of *S. crassisepta;* all American specimens examined are of the *crassisepta* type.

## Order VI. SIPHONALES.

Fronds filiform, usually much branched or developing into various forms, continuous without dissepiments in the vegetative condition, multinucleate, with many lens- or disk-shaped chromatophores.

### KEY TO THE FAMILIES OF SIPHONALES.

1. Sexual reproduction by motile gametes or unknown. 2.
1. Sexual reproduction by non-motile oospores and motile spermatozoids. 6. VAUCHERIACEAE.
   2. Frond differentiated into root, stem and branches, the latter of very varied form; reproduction unknown. 5. CAULERPACEAE.
   2. Frond filiform, branching; not differentiated as above. 3.
3. Filaments interwoven to form fronds of definite form. 1. CODIACEAE.
3. Filaments branching, not interwoven. 4.
   4. Sexual reproduction by large female and small male gametes; asexual reproduction unknown; branching more or less plumose. 2. BRYOPSIDACEAE.
   4. Sexual reproduction unknown; branching irregular. 5.
5. In tissues or shells of plants or animals; asexual reproduction by aplanospores. 4. PHYLLOSIPHONACEAE.
5. Free, marine; asexual reproduction by large, multicilate zoospores. 3. DERBESIACEAE.

## Family 1. CODIACEAE.

Frond except in the lowest forms of definite shape, composed of interwoven, continuous, branching filaments, sometimes apparently pluricellular by constrictions, calcified or not. Asexual reproduction by zoospores and aplanospores, formed in sporangia; sexual reproduction by zoogametes, the sexes either similar or differing in size.

KEY TO THE GENERA OF CODIACEAE.

1. Not calcified nor stipitate, soft and spongy; cortical layer formed of the swollen ends of the longitudinal filaments. Subfamily CODIOIDEAE. 1. CODIUM.
1. Stipitate or of seriate disks, often calcified; cortical layer, when present, formed of lateral branches, usually smaller than the longitudinal filaments. Subfamily UDOTOIDEAE. 2.
   2. Frond terminating in a penicillate tuft of free filaments. 3. PENICILLUS.
   2. Frond not terminating in free filaments. 3.
3. Frond of a branching series of disks. 7. HALIMEDA.
3. Disks terminal or wanting. 4.
   4. Frond terminating in numerous flat expansions. 4. RHIPOCEPHALUS.
   4. Frond not terminating in numerous flat expansions. 5.
5. No definite cortical layer. 2. AVRAINVILLEA.
5. Cortex present either on stipe or lamina. 6.
   6. Cortex of divaricate, labyrinthiform branches always present. 6. CLADOCEPHALUS.
   6. Cortex of lamina wanting, or of short, little divided branches. 5. UDOTEA.

## Subfamily CODIOIDEAE.

### 1. CODIUM Stackhouse, 1795, p. XVI.

Frond of spongy texture, of very varying form, consisting of branching, continuous filaments, their swollen ends, "utricles" closely packed to form a cortical layer; sexual reproduction by zoogametes, produced in subovoid sporangia, borne laterally on the utricles; large biciliate female gametes produced in sporangia with very dark green contents; small biciliate male gametes produced in sporangia with yellowish contents; male and female usually produced on distinct individuals, but occasionally on the same individual; by the union of the two sexes a zygote is produced, germinating immediately; no asexual reproduction is known, but is probable that female zoospores sometimes germinate parthenogenetically.

The species of *Codium* here recognized are based either on external form, which is more or less variable in each species, or on the size of the utricles, which varies within quite wide limits. It is probable that when the genus is thoroughly studied, present arrangements will be considerably changed.

KEY TO THE SPECIES OF CODIUM.

| | | |
|---|---|---|
| 1. | Forming a continuous expanded incrustation. | 2. |
| 1. | Not forming a continuous expanded incrustation. | 3. |
| 2. | Utricles usually 50-60 $\mu$, rarely 100 $\mu$ diam. | 1. *C. adhaerens.* |
| 2. | Utricles usually 125-200 $\mu$, rarely 300 $\mu$ diam. | 2. *C. difforme.* |
| 3. | Frond globose to pyriform. | 3. *C. Ritteri.* |
| 3. | Frond branched, cylindrical or compressed. | 4. |
| 4. | Frond creeping, attached by holdfasts. | 4. *C. repens.* |
| 4. | Frond erect. | 5. |
| 5. | All or part of the utricles mucronate. | 9. *C. mucronatum.* |
| 5. | Utricles blunt, smooth. | 6. |
| 6. | Branches usually constricted at base. | 6. *C. isthmocladum.* |
| 6. | Branches not usually constricted at base. | 7. |
| 7. | Frond normally cylindrical throughout; utricles seldom 200 $\mu$ diam. | 5. *C. tomentosum.* |
| 7. | Frond normally more or less compressed. | 8. |
| 8. | Utricles usually 400 $\mu$ diam. or more. | 7. *C. elongatum.* |
| 8. | Utricles usually less than 250 $\mu$. | 8. *C. Lindenbergii.* |

1. C. ADHAERENS (Cabr.) Agardh, 1822, p. 457; Harvey, 1846-51, Pl. XXXV.A; P. B.-A., No. 523. Forming an expanded, incrusting layer, closely adherent to the substratum, dark green, lubricous, increasing by marginal growth, with rounded lobes; the filaments and utricles united by firm gelatine; utricles clavate, 50-60, rarely 100 $\mu$ diam., sometimes with long, cylindrical lower part. On exposed rocks. Vancouver to Cal. *Europe, Asia, Oceanica.*

Forming a firm crust, about 1 cm. thick, on rocks; quite distinct from our other species, except *C. difforme*, which has a similar habit, but larger utricles.

2. C. DIFFORME Kützing, 1843, p. 300; 1856, Pl. XXXV, fig. 99; Vickers, 1908, p. 22, Pl. XXV. Habit like that of *C. adhaerens;* utricles 125-200, rarely up to 300 $\mu$ diam. Fla., W. I. *Mediterranean, warmer Atlantic, Pacific.*

Apparently a plant of warmer waters, while *C. adhaerens* extends considerably farther north.

3. C. RITTERI Setchell and Gardner, 1903, p. 231, Pl. XVII. Frond globose to pyriform, up to 3 cm. high, attached by a distinct stipe-like base, solid, the center consisting of a felt-like mass of fine filaments; utricles pyriform, blunt, 150-400 $\mu$ diam. older ones usually swollen in the middle, and with the mem-

brane at the tip somewhat thickened at the central part and projecting inwards. Alaska to Vancouver.

Nearest allied to *C. mamillosum* Harv., but that species has balloon-shaped utricles, 1-2 mm. diam.

4. C. REPENS Crouan in Vickers, 1905, p. 56; 1908, p. 23, Pl. XXIX; *C. tenue* var. *repens* Crouan in Mazé and Schramm, 1870-77, p. 107. Branching like that of *C. tomentosum* but branches prostrate and entangled, attaching themselves to the substratum by short special branches; utricles 150-300 $\mu$ diam. On rocks at low tide. Barbados, Guadeloupe.

5. C. TOMENTOSUM (Huds.) Stackhouse, 1795, p. 21, Pl. VII; Harvey, 1846-51, Pl. XCIII; 1858, p. 29, in part; Vickers, 1908, p. 22, Pl. XXVI; P. B.-A., No. 168. Frond erect, cylindrical, dichotomously branched, more or less fastigiate, surface smooth and soft; utricles obovate-clavate, 100-150 $\mu$, rarely 200 $\mu$ diam., 3-6 diam. long., apex obtuse, unarmed. N. C. to Fla.; W. I. *Europe, Asia, Africa, Oceanica.*

A cosmopolitan species, but many forms once included here have been removed, and it may be that a careful comparison would considerably reduce the number of localities for *C. tomentosum*. The principal distinctions from similar species are found in the cylindrical frond, and the unarmed tips of the utricles.

6. C. ISTHMOCLADUM Vickers, 1905, p. 57; 1908, p. 23, Pl. XXVIII. Frond dichotomously branched, the branches usually constricted at the base; utricles 200-300 $\mu$ diam. Barbados, Guadeloupe.

7. C. ELONGATUM Agardh, 1822, p. 454; Vickers, 1908, p. 22, Pl. XXVII; P. B.-A., No. 627. Frond dichotomously branched, often much elongate, younger divisions terete, older compressed, especially below the dichotomies, being there distinctly cuneate; utricles obovate-clavate, 300-400 $\mu$ diam., 5-6 times as long as the greatest diam. N. C. to Fla., W. I. *Europe, Africa, So. America.*

The younger plants resemble *C. tomentosum*, but the flattening is marked in older plants; in some cases all parts except the younger tips are quite broadly cuneate.

8. C. LINDENBERGII Binder in Kützing, 1856, p. 34, Pl. XCVII; P. B.-A., No. 628. Frond di- polychotomous, compressed or flat in all parts, segments cuneate, terminal linear-lanceolate; utricles clavate, 80-150 $\mu$ diam., 3-4 times as long as the greatest diam. Cal. *Africa.*

The fronds in this species are sometimes triangular or reniform and undivided; an extreme much beyond anything in *C. elongatum;* for ordinary forms the difference in size of utricles is sufficient distinction.

9. C. MUCRONATUM J. G. Agardh, 1886, p. 43. Frond cylindrical, more or less regularly dichotomously fastigiate, surface more or less roughish; utricles cylindric-clavate, 5-10 diam. long, terminating in a distinct mucro.

As described by Agardh, this species is divided between three varieties, with no definite typical form; it seems to take a place in the Pacific the same as that occupied by *C. tomentosum* in the Atlantic, and it is probable that most, if not all reports of the latter from the Pacific, really refer to this species.

Var. CALIFORNICUM J. G. Agardh, 1886, p. 44, Pl. I, fig. 3; P. B.-A., No. 229. Utricles in younger parts of the frond cylindrical, ending in a very acute mucro; in the older parts clavate, with a blunter mucro. Fig. 144. Alaska to Mexico.

Var. NOVAE ZELANDIAE J. G. Agardh, 1886, p. 44. Utricles in younger parts subcylindrical, with a short mucro; in older parts clavate, mucro wanting or very inconspicuous. Vancouver. *N. Zealand.*

In var. *californicum* the mucronate utricles are so well developed that the surface of the frond appears, even to the naked eye, not so smooth as that of *C. tomentosum.* In var. *novae zelandiae* they are much less noticeable, and some care is required to distinguish this variety from *C. tomentosum.*

### 2. AVRAINVILLEA Decaisne, 1842, p. 108.

Fronds not calcified, sessile or stipitate, coarse, greenish, brownish or blackish, composed of inarticulate, cylindrical or moniliform, dichotomous, interwoven filaments, terminating above in a somewhat flabelliform expansion or in digitate lobes, below in a mass of rhizoids or a rhizome; chromatophores minute, rounded or fusiform, usually with a pyrenoid; reproduction by aplanospores (?) formed in small number in sporangia terminal on short branches projecting from the surface.

A tropical genus of coarse, unsightly algae, growing abundantly in muddy shallow water, but extending also to considerable depths.

KEY TO THE SPECIES OF AVRAINVILLEA.

| | |
|---|---|
| 1. Upper part a distinct flabellum. | 2. |
| 1. Upper part digitately lobed. | 1. *A. Rawsoni.* |

2. Surface of flabellum smooth or smoothish. 3. *A. levis.*
2. Surface of flabellum velutinous, spongy or strigose. 3.
3. Interior filaments of flabellum moniliform. 2. *A. nigricans.*
3. Interior filaments of flabellum cylindrical with basal constrictions. 4. *A. longicaulis.*

1. A. RAWSONI (Dickie) Howe, 1907, p. 510, Pl. XXX; P. B.-A., No. 1481. Frond formed of more or less dense, terete, clavate or fusiform, digitate lobes, not developing a flabellum; filaments cylindrical to subtorulose, always strongly constricted just above a dichotomy, rather thin-walled, 30-70 $\mu$ diam.; color rather light green when growing, brownish or blackish when dried. W. I.

The digitately lobed frond, much resembling some of the common digitate sponges, sufficiently distinguishes this from our other species. The material distributed in P. B.-A., No. 770 as *A. longicaulis* and No. 771 as *A. nigricans*, was largely *A. Rawsoni*, but also with some *A. nigricans*, as now defined.

2. A. NIGRICANS Decaisne, 1842, p. 96; Howe, 1907, p. 508, Pl. XXVIII, figs. 8-25; *A. longicaulis* Murray and Boodle, 1889, p. 70, Pl. CCLXXXVIII, figs. 1-5. Flabellum suborbicular to cuneiform, irregularly and obtusely lobed; coriaceous, sessile or stipitate, from a more or less distinct subterranean rhizome; filaments very regularly moniliform; those of the interior 50-70 $\mu$ diam., near the surface about 30 $\mu$, with closer set constrictions; sporangia clavate to globose, 350-800 $\times$ 200-350 $\mu$; spores ovoid, pyriform, or elongate-ellipsoidal, 130-300 $\times$ 66-120 $\mu$. Color dark brown or blackish. W. I., Fla. *Brazil.*

A coarse and unsightly plant, forming dense growths under the surface of the mud in shallow sheltered waters; the tuber-like rhizome is usually infested with many minute animals. The texture of the flabellum is quite loose, not entirely opaque when held against the light.

Forma FULVA Howe, P. B.-A., No. 1480. Flabellum thicker, more spongy; stipe flatter, broader and less differentiated; filaments coarser, less regularly moniliform, more frequently and divaricately forked; color more yellowish. With the type. The sporangia noted above for this species were found on an individual of forma *fulva*.

3. A. LEVIS Howe, 1905a, p. 565, Pl. XXIII, fig. 1; Pl. XXVI, figs. 8-10; P. B.-A., No. 1478; *A. sordida* Murray and Boodle, 1889, p. 70.* Flabellum cuneiform-obovate to reni-

* *A. asarifolia* Börgesen, 1908, p. 34, fig. 4, Pl. III, is hardly to be distinguished from *A. levis*; the specimens of the latter distributed as P. B.-A., No. 1478 are not at the fullest development, but other specimens

form-orbicular with cordate base, 1-7 cm. wide, entire or somewhat lobed, compact, surface smooth or slightly wrinkled, generally zonate; stipe cylindrical or flattened, ½-4 cm. high, from a short base; filaments slender, 6-24 μ diam., in the interior up to 35 μ, cylindrical or slightly torulose; color olive or ashy brown. Fig. 147. W. I.

Externally distinguished by the shorter stipe, relatively broader lamina, and smoother surface; but as there is much variation in all these characters, inspection of the filaments is necessary for anything like certainty.

4. A. LONGICAULIS (Kütz.!) Murray and Boodle, 1889, p. 70; P. B.-A., No. 1479; *A. Mazei*, Murray and Boodle, 1889, p. 71; *Rhipilia longicaulis* Kützing, 1858, p. 13, Pl. XXVIII, fig. 2;* Flabellum cuneate or oblong, from a usually long stipe, up to 15 cm., sometimes but not always from a basal rhizome; filaments cylindrical, except for sharp constrictions above the forkings, 28-70 μ diam., the outer filaments sometimes down to 20 μ. W. I.

Distinguished from *A. nigricans* by the cylindrical filaments; in external characters the two are very similar, but *A. longicaulis* usually has a longer stipe, less developed rhizome, and more regularly cuneate flabellum. *A. levis* is generally a smaller plant and has a thinner flabellum, but sometimes it is necessary to determine the size of the filaments, which are much smaller in the latter species.

### 3. PENICILLUS Lamarck, 1813, p. 297.

Frond penicillate, with distinct, calcified stipe, from the top

from the same locality are large and well developed, and agree well in habit with *A. asarifolia*. The filaments of the latter are torulose, but in this respect *A. levis* varies considerably. In the same paper, p. 28, fig. 1, Börgesen notes under the name of *A. comosa* (Bail. and Harv.) Murray and Boodle, a single specimen from the Danish West Indies. *Chlorodesmis comosa* Bailey and Harvey has been reported from many stations in the Pacific, but this seems to be the only definite report of it in the North Atlantic. As Börgesen speaks of his plant differing in some particulars from the ordinary form, it may be well to suspend judgment for the present. Moreover, the inclusion of *Chlorodesmis comosa* in *Avrainvillea* by Murray and Boodle seems rather unnecessary, and it would certainly give the genus a much broader and less definite extension than that commonly received and here used. At p. 36, fig. 6, Börgesen mentions as *Avrainvillea sp?* a form which may well be included in *A. levis* as here understood.

* See Howe, 1905a, p. 586; 1907, p. 510, as to the type specimen of *Rhipilia longicaulis*; Murray and Boodle having first used the binomial *Avrainvillea longicaulis*, must be considered its authors, although the name does not belong to the plant to which they applied it.

of which issue in all directions, free, dichotomously branched filaments, inarticulate but with occasional constrictions; base a mass of rhizoids; reproduction unknown.

The characteristic brush-like form in the species of this genus easily distinguishes them from all our other algae except *Rhipocephalus;* in the latter the filaments are united into many fan-like expansions, while in Penicillus they are free, and issue in all directions; the species, however, are not very strongly marked, and it is often a matter of difficulty to decide to which of them a specimen is to be referred.

KEY TO THE SPECIES OF PENICILLUS.

1. Filaments stout but relatively scanty; stipe soft. 3. *P. Lamourouxii.*
1. Filaments of moderate size, abundant; stipe firm. 2.
   2. Stipe stout and short; head pyriform. 4. *P. pyriformis.*
   2. Stipe longer; head rounded. 3.
3. Stipe slender, smooth; filaments much calcified. 1. *P. capitatus.*
3. Stipe stout, rough; filaments slightly calcified. 2. *P. dumetosus.*

1. P. CAPITATUS Lamarck, 1813, p. 299; Harvey, 1858, p. 45, Pl. XLIII.B; P. B.-A., Nos. 271, 1475. Stipe up to 10 cm. high, slender, not over 5 mm. diam., smooth, cylindrical, having at the summit a subspherical head composed of slender, dichotomous filaments, usually 100-200 $\mu$ diam., with slight and distant constrictions, much calcified; stipe extending to the center of the head. Common in shallow water. Fig. 149. Fla., W. I.

2. P. DUMETOSUS (Lamour.) Decaisne, 1842, p. 97; Harvey, 1858, p. 44, Pl. XLIII.A; P. B.-A., No. 769. Stipe to 8 cm. high, 12-25 mm. diam., cylindrical or compressed, surface uneven and granular; at the summit a mass of dichotomous filaments about as long as the stipe, 500-800 $\mu$ diam., cylindrical or compressed, somewhat calcified, distinctly constricted at rather distant intervals. Fla., W. I.

A stouter species than *P. capitatus*, with shorter and rougher stipe, and larger head with larger and usually less calcified filaments. It is rather common in our warmer waters, but not as common as *P. capitatus*.

3. P. LAMOUROUXII Decaisne, 1842, p. 97. Stipe 3-4 cm. long, 6-8 mm. diam., smooth, rather soft and compressible, not penetrating the head; head globose, 3-4 cm. diam., filaments not abundant for the genus, 400-500 $\mu$ diam., ascending, strongly calcified. Bahama, Jamaica.

The soft stem, usually flattened or canaliculate when dried, and the stout but not very abundant filaments of the head, distinguish this from the other species.

Var. GRACILIS A. and E. S. Gepp, 1905, p. 2, Pl. CCCCLXVIII, fig. 2; P. B.-A., No. 1476. Filaments more abundant, 300-400 $\mu$ diam. With the type.

4. P. PYRIFORMIS A. and E. S. Gepp, 1905, p. 1, Pl. CCCCLXVIII, fig. 1; P. B.-A., No. 1477. Stipe 1-3 cm. long, 6-7 mm. thick, slightly compressed, hardly entering the head, surface rough; head pyriform, 5-7 cm. long, 3-4.5 cm. diam., dense, drying glaucous green; filaments calcified, ascending, densely interwoven, 150-200 $\mu$ diam. In shallow water. Fla., Bermuda, Bahama.

Resembles *P. capitatus*, but with shorter and relatively stouter stipe, not penetrating far into the head; the latter is pyriform rather than spherical, and the filaments are more densely matted.

4. RHIPOCEPHALUS Kützing, 1843, p. 311.

Frond with erect stipe, bearing at the summit a dense cluster of minute, cuneate, flabellate expansions, formed of the laterally united filaments; otherwise like *Penicillus*.

R. PHOENIX (Ell. and Sol.) Kützing, 1849, p. 506; P. B.-A., No. 1030; *Penicillus Phoenix* Harvey, 1858, p. 46, Pl. XLIII.C. Stipe to 10 cm. high, about 8 mm. diam., terete, slightly tapering upwards, strongly calcified, smooth; the upper part concealed by the round, oblong, or conical head; flabella composing the head 5-20 mm. long, calcified, monostromatic, each composed of the laterally united dichotomous ramification of a single basal filament; filaments 75-100 $\mu$ diam. Fig. 150. Fla., W. I.

The flabellately united filaments distinguish this from all species of *Penicillus*, and there is no other genus for which there is any danger of mistaking it; but it varies much in general dimensions, as well as in proportion of parts. In Gepp, 1905, p. 4, the following forms are indicated.

Forma TYPICUS Gepp, 1905, p. 4. Flabella about 15 mm. long, forming an oblong, smooth head.

Forma BREVIFOLIUS Gepp, 1905, p. 4. Flabella 5-10 mm. long, generally in densely imbricate, ascending whorls, forming an elongate-conical head; stipe percurrent through the head. Fla., Bahama, Guadeloupe, Jamaica.

Forma LONGIFOLIUS Gepp, 1905, p. 4, Pl. CCCCLXVIII, fig. 3. Flabella 20 mm. long and more, irregular, deeply and irregularly laciniate, ascending or divergent, forming a bristly head. Fla.

5. UDOTEA Lamouroux, 1813, p. 27.

Frond arising from a mass of rhizoids; stipe erect, with distinct cortex, terminating in a flabelliform, more or less distinctly zonate lamina, consisting of continuous, branching filaments with more or less numerous short branches, attached to each other by short processes, and sometimes developing laterally into a more or less definite cortex; calcification more or less complete; reproduction unknown.

Distinguished from *Avrainvillea* by the corticated stipe; from *Cladocephalus* by the cortex of the lamina, when present, not being formed of densely packed, labyrinthine branches as in the latter.

The evolution of all the forms of the subfamily Udotoideae from a branching filament like *Dichotomosiphon* is best shown in this genus. In the Mediterranean species *U. minima* Ernst the filaments are loosely united or often quite free; from this to *U. Flabellum*, with no external indication of the original filamentous structure, the intermediate stages can be seen in the different species. See Ernst, 1904, for a clear statement of the matter.

KEY TO THE SPECIES OF UDOTEA.

| | |
|---|---|
| 1. Whole flabellum with a stony coating. | 2. |
| 1. No general stony coating. | 3. |
| 2. Branches forming the cortex of the lamina capitate. | 6. *U. argentea.* |
| 2. Cortical filaments not capitate. | 5. *U. Flabellum.* |
| 3. Little or no calcification. | 1. *U. tomentosa.* |
| 3. Individual filaments of the flabellum calcified. | 4. |
| 4. Flabellum with a cortex of spinulose branches. | 4. *U. spinulosa.* |
| 4. Flabellum uncorticated. | 5. |
| 5. Flabellum plane. | 2. *U. conglutinata.* |
| 5. Flabellum concavo-convex to cyathiform. | 3. *U. cyathiformis.* |

1. U. TOMENTOSA (Kütz.) Murray, 1889, p. 239; Howe, 1907, p. 512. Fronds to 7 cm. high, bright green, uncalcified; stipe terete or flattened, 2-4 mm. wide, simple; flabellum cuneiform to obdeltoid, 3-5 cm. long, 1-3 cm. wide, entire or lobed, little or not at all zonate, rather thick, spongy, with tomentose

surface; filaments of flabellum 35-70 $\mu$ diam., the lesser branches more or less attached by short processes. W. I.

2. U. CONGLUTINATA (Soland.) Lamouroux, 1816, p. 312; Howe, 1909, p. 96, Pl. II; Pl. VIII, figs. 11-13; Fronds to 10 cm. high, greenish or whitish, more or less calcified; stipe subterete, above flattened and passing gradually into the cuneate base of the flat, cuneate to suborbicular, uncorticated, simple or somewhat lobed, usually zonate flabellum; longitudinal filaments of flabellum 28-60 $\mu$ diam., twisted and interwoven; branches of the stipe cortex slender, flexuous and tortuous, loosely and irregularly fastigiate, ultimate divisions digitate, subacute or taper-pointed. Fla., W. I.

To be carefully distinguished from *U. cyathiformis*, which is sometimes quite like it in habit; the characters of the cortex of the stipe should determine in such cases.

3. U. CYATHIFORMIS Decaisne, 1842, p. 106; Howe, 1909, p. 96, Pl. III; Pl. VIII, figs. 8-10; *U. conglutinata* Vickers, 1908, p. 24, Pl. XXXII; P. B.-A., No. 1482; ? *U. conglutinata* Harvey, 1858, Pl. XL.C. Frond up to 15 cm. high, greenish, becoming whitish, moderately calcified; stipe subterete, passing abruptly into the concavo-convex to cyathiform, entire or laciniate-fimbriate, only slightly zonate, uncorticated flabellum; longitudinal filaments of the flabellum 40-125 $\mu$ diam., usually 60-100 $\mu$, nearly straight, parallel and rigid; branches of the stipe cortex cymose-fastigiate, ultimate divisions very short, apices truncate, obtuse or truncate-capitate, seldom over 50 $\mu$ long. Fig. 154. Fla., W. I.

The cup-shaped form, from which this species has its name, is sometimes hardly perceptible; but the other characters are more uniform.

4. U. SPINULOSA Howe, 1909, p. 97; Pl. IV, fig. 2; Pl. VIII, figs. 1-7. Frond up to 8 cm. high, grayish-green, strongly calcified; stipe subterete, flattened above and passing gradually into the cuneate base of the flat, obovate, longitudinally striate but hardly zonate, corticated flabellum; longitudinal filaments of the flabellum 48-64 $\mu$ diam., parallel or interwoven, thickly beset externally with short processes crowned with acuminate spines; branches of the stipe cortex 4-6 times dichotomous, ultimate divisions taper-pointed, up to 200 $\mu$ long. Bahamas.

In habit somewhat like *U. conglutinata* and *U. cyathiformis*, but quite distinct by the well developed cortex of short, spinous branchlets.

5. U. FLABELLUM (Ell. and Sol.) Howe, 1904, p. 94; *U.*

*flabellata* Lamouroux, 1816, p. 311, Pl. XII, fig. 1; Harvey, 1858, p. 26; P. B.-A., No. 272. Frond up to 15 cm. high, stipe short, often indistinct; flabellum entire and cuneate-reniform or divided into a few similar lobes; longitudinal filaments of the flabellum flexuous, rather distant, their short ramuli forming a cortical layer, the whole covered with a stony incrustation. Fla., W. I.

Not to be mistaken for any other of our species, none of which have the general stony coating.

6. U. ARGENTEA Zanardini, 1858, p. 290, Pl. XII, fig. 1; Howe, 1909, p. 99; Gepp, 1909, p. 386. Calcified; stipe short; frond thin, subreniformly flabellate, longitudinally striate, only slightly zonate, repeatedly proliferous; lateral branches of main filaments abundant, each terminating in a capitate or ungulate head. W. I. *Red Sea, Indian Ocean.*

Among our better known species *U. Flabellum* is nearest to *U. argentea*, but the latter has a shorter stipe, is of thinner texture with more manifest radiate markings, along which it appears sometimes to divide; as it is plentifully proliferous from the margin, a single plant may develop into an apparent colony. Structurally it is distinguished by the capitate form of the branches composing the cortex.

### 6. CLADOCEPHALUS Howe, 1905a, p. 569.

Not calcified; frond arising from a mass of rhizoids; stipe erect, with central layer of parallel, dichotomous filaments, and distinct cortical layer of much narrower, intricate, divaricately dichotomous branches; surmounted by either a distinct flabellum or a brush-like head.

The species with brush-like head resemble *Penicillus*, but are uncalcified; the flabellate species have the habit of *Udotea*, but are distinguished by the more definite cortex of characteristic structure, as well as by the lack of calcification.

KEY TO THE SPECIES OF CLADOCEPHALUS.

1. With brush-like head. 1. *C. scoparius.*
1. With flabellum. 2. *C. luteo-fuscus.*

1. C. SCOPARIUS Howe, 1905a, p. 569, Pl. XXV, XXVI, figs. 11-20; P. B.-A., No. 1334. Stipe 2-10 cm. high, 5-7 mm. thick, cylindrical or somewhat complanate, often alate or canaliculate above, sometimes forked; head 3-8 cm. long, brush-like, in shape from linear or fusiform to obovoid, more or less flattened; branches subcylindrical or complanate, up to 2 mm.

broad, often connate; color dark green to blackish, easily fading to yellowish; filaments of medulla of stipe cylindrical to slightly torulose, 30-75 $\mu$ diam.; filaments of cortex cylindrical, diminishing in ultimate branches to 6-11 $\mu$ diam. In quiet pools. Bahama.

Börgesen suggests that this may be a battered state of the following species, but an examination of a large number of specimens of all sizes and ages shows no indication of such a relation.

2. C. LUTEO-FUSCUS (Crouan) Börgesen, 1908, p. 40, figs. 7 and 8; *Udotea luteo-fusca* Howe, 1907, p. 513. Fronds to 10 cm. high, brownish; stipe simple or 1-3 times dichotomous, terete or flattened; flabellum cuneate to irregularly orbicular, little or not at all zonate, surface smooth or slightly rugulose; filaments of medulla of stipe 50-80 $\mu$ diam., the repeatedly dichotomous branches forming the cortex diminishing in the ultimate divisions to 4-10 $\mu$ diam.; structure of the flabellum similar. Fig. 151. W. I.

### 7. HALIMEDA Lamouroux, 1812, p. 186.

Frond much calcified, consisting of more or less flattened segments in branching series; with a more or less distinct stem and a mass of basal rhizoids. A central strand of inarticulate filaments passes through each segment, giving out lateral branches whose terminations form the surface of the segment, and superficially appear like hexagonal cells. At the apex of each segment the central filaments come into connection with each other, but separate when forming the next segment. Fructification by globose or obovoid sporangia, borne on the margin or on the face of a segment, on branches from the central filaments, producing biciliate spores, whose development is unknown.

The species of *Halimeda* are all tropical or subtropical; they are conspicuous plants, and the Mediterranean species was described over 300 years ago, though it was only in the last century that it was recognized as a plant. About 20 species have been described, based on the external form of the frond, but this is so variable, characters of several supposed species being sometimes found on one individual, that there has been much confusion. By using chiefly characters derived from the central filaments, and from the size and shape of the ultimate segments of their branches, "peripheral utricles," ten species can be distinguished in the Florida-West India region, and fairly distinct habit characters can usually be found, but doubtful cases requiring decalcification and microscopical examination are not uncommon.

KEY TO THE SPECIES OF HALIMEDA.

1. Branching in more than one plane. 7. *H. Opuntia.*
1. Branching in one plane only or with few exceptions. 2.
  2. Peripheral utricles cuspidate. 8. *H. scabra.*
  2. Peripheral utricles not cuspidate. 3.
3. All segments except those bearing branches cylindrical. 2. *H. Monile.*
3. Most segments ovoid or flattened, not cylindrical. 4.
  4. Peripheral utricles over 150 $\mu$ diam.; dried frond showing pitted surface when slightly magnified. 10. *H. favulosa.*
  4. Peripheral utricles not over 80 $\mu$ diam.; surface not pitted. 5.
5. Segments distinctly ribbed. 1. *H. tridens.*
5. Segments indistinctly or not at all ribbed. 6.
  6. Segments slender, cuneate to cylindrical. 3. *H. gracilis.*
  6. Segments broader, often broader than long. 7.
7. Very slightly calcified; color pale. 6. *H. discoidea.*
7. More calcified; color darker. 8.
  8. Segments mostly with crenulate, dentate or lobed margins. 9. *H. simulans.*
  8. Segments mostly with entire margins. 9.
9. Segments thin, more or less cuneate, moderately calcified. 5. *H. Tuna.*
9. Segments obovoid, pyriform or globose, heavily calcified. 4. *H. lacrimosa.*

1. H. TRIDENS (Ell. and Sol.) Lamouroux, 1812, p. 186; Harvey, 1858, p. 24, Pl. XLIV.C.; P. B.-A., No. 1487. Plants up to 20 cm. high, thickly calcified, especially below, branched in one plane, very variable in habit. Segments ribbed, tridentate, cuneate or discoid, often welded together near the base; lower segments cylindrical, up to 8 mm. diam.; tridentate segments up to 14 mm. wide. Filaments of central strand either communicating with each other at apex of segment by pits, or rarely free throughout; peripheral utricles 49-77 $\mu$ diam., rather loosely attached, in contact for one-eighth to one-twentieth of their length; sporangia obovoid or pyriform, 200-380 $\mu$ diam., color dark yellow or brown, on rather long, several times dichotomous pedicels. Fla., W. I. *All warm seas.*

Forma **typica** (Barton) nov. comb.; *H. incrassata* forma *typica* Barton, 1901, p. 27. Lower segments cylindrical; upper segments more or less trilobed.

Forma **tripartita** (Barton) nov. comb.; *H. incrassata* forma *tripartita* Barton, 1901, p. 27, Pl. IV, fig. 43. Lower segments cylindrical; upper segments often tripartite, deeply cut, divisions cylindrical.

A common and variable species, of which forms with broader and tridentate segments have been known as *H. tridens*, those with many cylindrical segments as *H. incrassata*. Both forms are found together in Florida and the West Indies.

2. H. MONILE Lamouroux, 1812, p. 186; P. B.-A., No. 1488. *H. incrassata* forma *monilis* Barton, 1901, p. 27, Pl. IV, fig. 40. Plants up to 20 cm. high, much calcified; branching in one plane; segments cuneate or tridentate when bearing branches, all others cylindrical, up to 8 mm. long, 1-2 mm. diam. Peripheral utricles 30-44 $\mu$ diam., adherent for one-third to one-tenth their length, not easily separable: filaments of central strand connected by pits. Fla., W. I.

The habit is usually quite distinct from that of *H. tridens*, with which it has been generally associated; in occasional doubtful cases, microscopic examination is needed.

3. H. GRACILIS Harvey, Ceylon Algae, No. 72; Barton, 1901, p. 22, Pl. III, figs. 28-32; Vickers, 1908, p. 24, Pl. XXXIV. Fronds of varying length up to 40 cm., much calcified below, upper segments less; branched in one plane; segments cuneate to subcylindrical, not ribbed, $\frac{1}{2}$-9 mm. long, $1\frac{1}{2}$-11 mm. wide. Filaments of central strand fused in pairs, single fused filaments branching later trichotomously; peripheral utricles 30-45 $\mu$ diam. St. Thomas, Barbados.

Reported from only two localities within our range, but likely to be found at other points. It has probably been taken for a slender, loosely branched *H. Opuntia* or *H. tridens*; the only sure test would be by microscopic examination.

4. H. LACRIMOSA Howe, 1909, p. 93, Pl. V, fig. 1; Pl. VI, figs. 3-11. Plants up to 5 cm. high, strongly calcified; branching mostly but not exclusively in one plane. Segments obovoid, pyriform or subglobose, occasionally subterete, 1-5 mm. long and broad, solid and stony or the larger ones hollow; surface smooth and compact. Filaments of central strand fusing in twos or threes at the nodes, sometimes with secondary incomplete fusions; peripheral utricles obconical, 40-110 $\mu$ long, 33-37 $\mu$ diam., in contact for one-tenth to one-thirtieth of their length; subcortical utricles in a single series, 66-110 $\mu$ diam. W. I.

A species not closely related to any of the foregoing; externally characterized by the mostly spherical or broadly pyriform segments. It appears to be a plant of deeper water than most species of the genus.

5. H. TUNA (Ell. and Sol.) Lamouroux, 1812, p. 186; ? Harvey, 1858, p. 25, Pl. XL.A; P. B.-A., No. 1484. Plants not usually over 10 cm. long, moderately calcified, branching in one plane; a few of the lower segments thick, the others thin, about 1 mm., varying in form but mostly cuneate, not ribbed, margin entire. Filaments of central strand fused in twos or threes at the apex of each segment; peripheral utricles 30-70 $\mu$ diam., adherent for one-twenty-fifth to one-tenth of their length, rather easily separable; utricles of subcortical layer 35-110 $\mu$ diam.; sporangia globose to pyriform, 200-330 $\mu$ diam., deep green, borne on simple or forked pedicels, on margin or surface of the segments. Fla., W. I. *Europe, Asia.*

The group including *H. Tuna*, *H. discoidea* and *H. scabra* is generally distributed in all warm waters, and distinguished by thin, not heavily calcified segments. The roughened surface distinguishes *H. scabra*, the slight calcification *H. discoidea*.

6. H. DISCOIDEA Decaisne, 1842, p. 102; Howe, 1907, p. 495, Pl. XXVI; P. B.-A., No. 1483. Plants reaching 15 cm. in length and width, very slightly calcified, color bright green, fading when dry; branched in one plane; segments deltoid to elliptical with long axis transverse, up to 35 mm. broad, thin, smooth, shining. Filaments of central strand fused in twos, rarely threes, at the nodes; peripheral utricles 40-85 $\mu$ diam., often fusing, in contact with each other for one-fifth to two-thirds their length, not easily separated. Utricles of subcortical layer relatively large, bullate, 110-215 $\mu$ diam. Fla., W. I. *Asia, Africa.*

Resembling *H. Tuna*, but less calcified and of thinner texture; the segments vary much in size, the largest are broader than long, and of greater dimensions than in *H. Tuna*; in cases where the habit is not distinctive the shape and dimensions of the utricles may be depended on to decide.

7. H. OPUNTIA (L.) Lamouroux, 1812, p. 186; Harvey, 1858, p. 23, Pl. XL.B; Vickers, 1908, p. 25, Pl. XXXV; P. B.-A., No. 123. Plants usually 10 cm. high, sometimes up to 25 cm.; more or less branched in various directions; segments much calcified, very variable in shape; discoid, cordate or trilobed; more or less plainly ribbed; up to $12 \times 20$ mm. Fila-

ments of central strand fused in pairs at the apex of each segment; peripheral utricles 20-50 $\mu$ diam. Fig. 156. Fla., W. I.

Generally distributed in all warm waters; forming dense tufts, by branching in more than one plane.

8. H. SCABRA Howe, 1905, p. 241, Pls. XI, XII; P. B-A., No. 1485. Frond up to 25 cm. long, dichotomously, usually much branched, always in one plane; segments strongly calcified, not ribbed, reniform, suborbicular, occasionally deltoid-obovate, up to 14 mm. broad, 1.5 mm. thick; filaments of central strand fused in twos and threes at the joints; peripheral utricles 27-50 $\mu$ diam., each prolonged into an acuminate, often indurated terminal cusp; in contact for only a small portion of their length, rather easily separated; sporangia pyriform, 160-320 $\mu$ diam., usually distichously arranged on simple or forked pedicels, covering the margin, rarely the disk of a segment. Fla., W. I.

This species has passed under the name of *H. Tuna*, but is amply distinct by the cuspidate peripheral utricles, which are visible under a good lens, and give a rougher feeling to the plant than is found in the smooth-utricled *H. Tuna*. The material distributed as P. B.-A., No. 167, is partly this species, partly *H. discoidea*.

9. H. SIMULANS Howe, 1907, p. 503, Pl. XXIX; P. B.-A., No. 1486. Plant up to 15 cm. high, strongly calcified, flabellate in outline, branching in one plane; segments discoid, plane or somewhat 1-3-nerved, subquadrate to obovate in outline, usually broader than long, margin entire, crenulate, dentate or lobed; up to 12 mm. wide, to 2 mm. thick; peripheral utricles 33-40 $\mu$ diam., in contact one-third to one-tenth of their length, rather firmly adhering. Filaments of the central strand coherent at the nodes, connecting by open pits or very short tubes. W. I.

Individuals of this species often resemble *H. Tuna* or *H. tridens* in some habit characters, but it is seldom that there is doubt on considering all the characters.

10. H. FAVULOSA Howe, 1905a, p. 563, Pl. XXIII, fig. 2; Pl. XXVI, figs. 1-6. Fronds up to 20 cm. high, rather thickly calcified, branching densely in one plane; segments varying much in form, cylindrical to trilobed or discoid, up to 9 mm. long and broad, and 2 mm. thick. Filaments of central strand connected at the joints by very short processes; peripheral utricles 110-260 $\mu$ across. Bahama.

In habit much like *H. tridens*, but readily distinguished by the large peripheral utricles, easily seen with slight magnification. In dried plants they collapse, the calcareous framework resembling a honeycomb; the surface of *H. tridens* seems quite smooth unless considerably magnified.

## Family 2. BRYOPSIDACEAE.

Vegetative frond unicellular, much branched; chromatophores numerous small disks, each with one pyrenoid; the axis producing below rhizoids, and above branches both of unlimited and limited growth; in the latter large biciliate, green, female gametes, and on separate individuals, smaller, brown, biciliate male gametes are formed; by the union of the two a zygote is formed, germinating immediately. Only one genus with us.

### BRYOPSIS Lamouroux, 1809, p. 129.

Characters of the family; marine.

A genus mostly of warm waters, some few species extending into and throughout the temperate zone; mostly attractive plants with symmetrical form, glassy membrane and rich color. The forms of our region group themselves around two types: *B. plumosa* with firm, distichous ramuli, not much smaller than the branch from which they issue; *B. hypnoides* with more flaccid ramuli, not distichous, generally more slender than the branch from which they issue. Whether our forms should all be considered as varieties of these two species, or whether we have a number of distinct species, as given below, can be determined only by careful study of living plants.

KEY TO THE SPECIES OF BRYOPSIS.

1. Ramuli not distichous. 2.
1. Ramuli distichous, generally unbranched. 4.
   2. Ramuli long, not distinct in character from the branch bearing them. 1. *B. hypnoides*.
   2. Ramuli short. 3.
3. Ramuli forming a dense coating on the stouter, virgate branches. 2. *B. Duchassaingii*.
3. Ramuli scattered, alternate, or in short, secund series. 5. *B. ramulosa*.
   4. Corticating rhizoidal filaments abundant at the base of the branches and ramuli. 4. *B. corticulans*.
   4. Corticating filaments inconspicuous. 5.
5. Ramuli in short, subdistant series. 6. *B. Leprieurii*.
5. Ramuli mostly in one continuous series. 6.

6. Ramuli forming a distichous plumule. 7.
6. Ramuli forming an apparently secund plumule. 8.
7. Plumule linear to linear-lanceolate; stems seldom branched. 7. *B. pennata.*
7. Plumule usually triangular; stems generally freely branched. 3. *B. plumosa.*
8. Ramuli forming a plumule over all but the base of the rachis. 9. *B. foliosa.*
8. Ramuli in a short series below the naked, often incurved tip. 8. *B. Harveyana.*

1. B. HYPNOIDES Lamouroux, 1809, p. 135, Pl. I, fig. 2, a and b; Harvey, 1846-51, Pl. CXIX; Vickers, 1908, p. 30, Pl. LIII; P. B.-A., Nos. 1028, 1286; not 474. Frond seldom over 10 cm. high, soft, rather pale green, usually much branched, branches in no definite order, growing smaller in the successive series, and with no sharp division between the lesser branches and the ramuli that clothe them on all sides, and themselves branch more or less. Southern Mass. to W. I.; Washington to southern Cal. *Europe.*

A common European species, considered rare on our Atlantic coast, but probably often mistaken for *B. plumosa.* There is little distinction between the various orders of branches, and though the plant is delicate and graceful, there are none of the definite plumules characteristic of *B. plumosa* and its allies.

2. B. DUCHASSAINGII J. G. Agardh, 1854, p. 107; 1886, p. 31; *B. hypnoides* P. B.-A., No. 474, not 1028, 1286; *Trichosolen antillarum* Montagne, 1860, p. 171, Pl. XI.C. Frond up to 20 cm. high, rather pale green; stem stout, main branches long, virgate, with one or more series of similar branches, covered in the upper part with a woolly coating of short ramuli, shorter towards the end of the branch, giving the branch a linear or linear-lanceolate outline with acute tip; also with numerous short, slender, secondary branches, bare below, the upper part densely covered with minute ramuli. Fla., W. I.

The main stems are stouter than in *B. hypnoides*, the ramuli are shorter and denser, the branches virgate and not much divided. The branches vary much in length, and the frond does not have the regular outline usually found in most species of *Bryopsis.*

3. B. PLUMOSA (Huds.) Agardh, 1822, p. 448; Harvey 1846-51, Pl. III; 1858, p. 31; Farlow, 1881, p. 59, Pl. IV, fig. 1; P. B.-A., No. 227. Frond seldom over 10 cm. high, rich and glossy green; amount of branching variable; typical forms

with numerous lateral branches and often a second series; all branches with abundant distichous ramuli, shorter above, giving the branches a triangular outline. Fig. 155. Me. to Fla.
*Europe.*

The best known and most widely distributed species of the genus, and to which may possibly be referred, as forms, quite a number of less familiar species, so now regarded. It is nowhere very abundant, but occurs in various stations; rocky tide pools, muddy shores, wood work of wharves, etc. In its northern range it seems to be more specially a summer plant, but is sometimes found at any season.

4. B. CORTICULANS Setchell, P. B.-A., No. 626. Frond rather stout and coarse, up to 20 cm. high, dark green in the growing parts, glossy throughout; main stems not much divided, lower part naked, upper part, usually about half of the whole length, with abundant patent, generally opposite branches, naked below, above with rather stout, distichous ramuli, decreasing in length towards the tip of the branch; general outline of frond and of individual branches pyramidal; conspicuous tufts of descending rhizoidal filaments found at the bases of the branches. Vancouver to Cal.

Resembling *B. plumosa*, under which name the distichously branched plant of the Pacific coast has usually been distributed; but it is a larger and coarser plant than the *B. plumosa* of the Atlantic, and the corticating filaments are much developed, not exceptional as in *B. plumosa*. Unfortunately, these differences are of the same character as are often found between Atlantic and Pacific forms of what passes for the same species; whether they are of specific importance in this case can hardly be determined at present.

5. B. RAMULOSA Montagne, 1838a, p. 16, Pl. III, fig. 2; *B. plumosa* var. *ramulosa* Harvey, 1858, p. 31, Pl. XLV.A., figs. 4-6. Fronds densely tufted, little branched, rather coarse, dark green; ramuli uniformly short, scattered, in longer or shorter secund series, or in occasional opposite pairs; mostly in the middle of the filament, seldom in the lower part or at the tip. Fla., W. I.

Ramuli very short and inconspicuous, so that the fronds seem like depauperate or denuded specimens of some other species.

6. B. LEPRIEURII Kützing, 1849, p. 490; 1856, Pl. LXXV, fig. 2; Vickers, 1908, p. 29, Pl. L. Fronds up to 15 cm. high,

rather sparingly branched, often undulately curved and swollen in places; ramuli rather short, blunt, in secund series of a few each, the rachis naked between the series. W. I.

*So. America.*

The four species, *B. foliosa*, *B. pennata*, *B. Leprieurii* and *B. Harveyana* are certainly closely related; only continued study of the living plants will settle the question of their distinctness. That the three last named are kept separate here is chiefly due to their being so kept by Miss Vickers, who studied and collected them at Barbados.

7. B. PENNATA Lamouroux, 1809, p. 134, Pl. III, fig. 1; Vickers, 1908, p. 30, Pl. LII; *B. pennatula* J. G. Agardh, 1848, p. 6. Fronds seldom over 5 cm. high, tufted, simple or nearly so, bearing, except at the very base, rather short, densely set, distichous ramuli of uniform length, giving a linear outline to the frond. W. I., Mexico.

The narrow subsimple frond reminds one of the European *B. myura*; but the distichous ramuli place it near *B. plumosa*.

8. B. HARVEYANA J. G. Agardh, 1886, p. 22; Vickers, 1908, p. 29, Pl. LI; P. B.-A., No. 1532; *B. plumosa* var. *secunda* Harvey, 1858, p. 31, Pl. XLV.A, figs. 1-3. Fronds up to 15 cm. high, dark green, growing in dense tufts; main stems moderately and rather irregularly branched, branches bearing near the end rather short, distichous ramuli, the general outline being linear-lanceolate, or linear with rounded ends, the tip of the branch somewhat prolonged. This tip is usually somewhat incurved, and the ramuli on both edges of the rachis turn inwards towards one side of the latter, so that unless closely examined they appear secund. Fla., W. I.

The characters by which this is distinguished from *B. plumosa* are not as sharp nor as constant as might be wished; but well developed plants seem quite distinct by their densely tufted, little branched fronds, each filament with scorpioidal-appearing tip.

9. B. FOLIOSA Sonder, 1845, p. 49. Frond 2-3 cm. high, ascending from more or less abundant creeping filaments; usually simple, occasionally once or twice forked, tip somewhat incurved, base naked, but with scars of fallen ramuli; upper part thickly set with ramuli, arising dichotomously on the rachis, but curving immediately, and all turned in the same direction, so as to appear secund on the outer, convex, side of the rachis; ramuli slender, patent, the lowest longest, up to 5 mm.,

generally simple, occasionally with a few rudimentary ramelli. Guadeloupe. *Australia.*

The ramuli in this species originate in the same way as in *B. plumosa*, but instead of continuing the distichous arrangement, both series bend towards the same side, until their direction is the same, and the branching appears secund. *B. Harveyana* has the same branching, but the ramuli are stouter, and instead of forming a definite plumule over all but the base of the rachis, occur in short series, below the naked tip. This species is here included from the reference in Agardh, 1886, p. 26, and the description there given is copied; the original description by Sonder is very meager; it is not clear just how it is to be distinguished from forms of *B. Harveyana*.

## Family 3. DERBESIACEAE.

Frond filiform, unicellular or with occasional partitions, multinucleate, simple or branched, with no differentiation of axis and branches; chromatophores numerous disks, with or without pyrenoids; asexual reproduction by large, multiciliate zoospores, each with one nucleus, formed in lateral cells partitioned off from the filaments. Only one genus.

### DERBESIA Solier, 1847, p. 158.

Characters of the family. Marine.

#### KEY TO THE SPECIES OF DERBESIA.

1. Filaments 100-600 $\mu$ diam. 3. *D. Lamourouxii.*
1. Filaments less than 100 $\mu$ diam. 2.
   2. Branching mainly dichotomous; pedicel of sporangium about 15 $\mu$ diam. 1. *D. vaucheriaeformis.*
   2. Branching mainly lateral; pedicel 25-35 $\mu$ diam. 2. *D. marina.*

1. D. VAUCHERIAEFORMIS (Harv.) J. G. Agardh, 1886, p. 34; P. B.-A., No. 318; *D. tenuissima* Farlow, 1881, p. 60, Pl. IV, fig. 4; *Chlorodesmis vaucheriaeformis* Harvey, 1858, p. 30, Pl. XL.D. Filaments erect, 40-50 $\mu$ diam., dichotomously branched, up to 4-5 cm. high, in dense fastigiate tufts; on one or both branches, a short distance above the forking, two partitions are often formed, the space between being 30-35 $\mu$ in length, and about the same diam. Sporangium formed in the place of a branch, ovoid or broadly pyriform, 190-300 $\times$ 100-130 $\mu$, supported by a slender pedicel, about 15 $\mu$ diam., 50-100 $\mu$ long, in which two partitions, similar to those at the base of a branch, enclose a cell 2-4 times as long as broad; spores large, about 15 in a sporangium. Southern Mass., Fla.

In appearance not unlike a *Vaucheria*, but of more erect habit, and lacking the elaborate sexual apparatus of that genus.

2. D. MARINA (Lyng.) Kjellman, 1883, p. 316; *D. tenuissima* P. B.-A., No. 574.* Arising from a more or less distinctly developed layer of irregular creeping cells; erect filaments bright green, 50-70 $\mu$ diam., sometimes simple but usually with a few lateral branches similar to the axis; a cell partitioned off frequently near the base of a branch, and occasionally in the axis just above a branch, not much smaller than the branch, about as long as broad; sporangium occupying the place of a branch, 150-250$\times$90-200 $\mu$, from obovoid to subspherical; pedicel varying from 30-70 $\mu$ in length, 30-35 $\mu$ diam., the cell formed in it being about as long as broad; spores 20 or more in a sporangium. Fig. 152. Alaska to Southern Cal. *Europe.*

3. D. LAMOUROUXII (J. Ag.) Solier, 1847, p. 162, Pl. IX, figs. 18-30; *Bryopsis simplex* Rabenhorst, Algen, No. 916. Filaments arising from a creeping base, from a few cm. to 2 dm. high, 100-600 $\mu$ diam., dark green, rather stiff, sometimes simple, sometimes with more or less numerous irregular branches; sporangia globose, 300-550 $\mu$ diam., sessile or on a short and slender pedicel. Southern Cal. *Europe.*

Distinguished from our other species by the much larger filaments. Only sterile plants have yet been found here, and though they agree very well with the Mediterranean plant, the identification is uncertain until fruit is observed.

## Family 4. PHYLLOSIPHONACEAE.

Frond filiform, inarticulate, branching; perforating the shells of mollusks, or parasitic in the tissues of plants; asexual reproduction, known only in one genus, by aplanospores.

The family was founded on the genus *Phyllosiphon;* the inclusion of *Ostreobium*, so totally different in its habitat, may seem hardly warranted; but the two resemble each other in the form of the vegetative frond more than they do any other genus; the reproduction of *Ostreobium* being quite unknown, the present place is as suitable as any for it, temporarily.

KEY TO THE GENERA OF PHYLLOSIPHONACEAE.

1. Parasitic in the tissues of plants. 1. PHYLLOSIPHON.
1. Perforating the shells of mollusks. 2. OSTREOBIUM.

* *D. tenuissima* (De Not.) Crouan, of southern Europe, has sporangia sessile, without the short cell.

1. PHYLLOSIPHON Kühn, 1878, p. 32.

Parasitic in the leaves and stems of flowering plants; ends of the filaments and their branches without chlorophyll, lower parts with chlorophyll, but with little indication of definite chromatophores; asexual reproduction by aplanospores, with distinct parietal chromatophore, escaping by rupture of cell wall.

P. ARISARI Kühn, 1878, p. 32; Just, 1882, p. 1, Pl. I; P. B.-A., No. 1285. Filaments 25-35 $\mu$ diam., during spore formation up to 60 $\mu$ diam., irregularly or dichotomously branched, creeping between the cells in the parenchyma of the leaf or petiole of the host plant; forming larger or smaller yellowish patches, up to several cm. diam., each patch formed of a single individual; aplanospores formed in great numbers, ovoid, about $5 \times 2.5$ $\mu$; development unknown. Fig. 157. N. H. *Europe.*

In Europe this plant infests *Arisarum vulgare;* here the nearly allied *Arisaema triphyllum.* In spite of its abundant chlorophyll it appears to be a true parasite, drawing its supplies from the cells of the host plant, which it ultimately exhausts; but it does not penetrate the cells, nor are there any specialized haustoria.

2. OSTREOBIUM Bornet and Flahault, 1889, p. CLXIII.

Fronds tubular, branched, with occasional swellings; living in the shells of mollusks; reproduction unknown.

O. QUEKETTII Bornet and Flahault, 1889, p. CLXIII, Pl. IX, figs. 5-8. Fronds slender, in main divisions 4-5 $\mu$ diam., with numerous lateral, divaricate branches, which by repeated branching form a close network, the ultimate divisions about 2 $\mu$ diam.; occasional irregular swellings in the filaments, 20-40 $\mu$ diam. In old shells of oysters and other mollusks. Fig. 159. Mass., Conn. *Europe.*

This species often grows in company with *Gomontia polyrhiza*, from which it is easily distinguished by the continuous, not cellular filaments; the swellings would seem to indicate reproductive organs of some sort, but nothing has been found in them different from the contents of the more slender parts.

## Family 5. CAULERPACEAE.

Frond tubular, multinucleate, unicellular, traversed by cross strands of cellulose. Reproduction by division of the frond; no other method known. Containing only one genus.

CAULERPA Lamouroux, 1809a, p. 30.

Frond composed of a creeping stolon (wanting in one species), giving out rhizoids below and branches above. The latter of various form, usually erect, but sometimes prostrate; simple or branched. Marine.

A remarkable genus, of many species of very diverse shape and degree of vegetative differentiation, but all constructed on the type of a creeping rhizome-like stem, giving out filamentous rhizoids below, and erect branches above. For the latter the word "frond" will be used in the following pages, in a special limited sense. These fronds vary from the simplest filaments to very elaborate branching structures, often simulating to a surprising degree the forms of higher plants, so that most of the sections of the genus are named for these resemblances, and these names often give as good an idea of the habit as can be obtained from technical descriptions. The entire plant, however differentiated, is continuous throughout, not divided into cells, and the only propagation known is by the breaking off from the frond of some part, which continues to grow as a distinct individual. Pieces of either rhizome or frond can develop in this way, so that, in one sense, all the plants on a whole stretch of coast may be a single individual, broken up by various causes.

While very various types of form are found in various species, the lines cannot be sharply drawn, one form passing insensibly into another. Being tropical or subtropical plants, much the greater part of the species have been founded on dried specimens only, often very fragmentary and insufficient specimens, obtained by collectors by no means specialists in algae. Thus it has frequently happened that species have been founded on specimens showing markedly different characters, while later investigation has brought to light plants with fronds of both types growing from the same stem.

The careful revision of the genus by Mme. Weber van Bosse, 1898, founded largely on the study of living plants and by comparison of practically all the original specimens, has been followed in the following descriptions. Many varieties and forms are given in her work, corresponding largely to former species, but with the note that too much stress should not be laid on them, except as indicating special lines or limits of variation. A short characterization of all the sections is given below, but three sections are not yet represented in North America: Sect. 4, Zosteroideae, Africa and Spain; Sects. 7 and 10, Hippuroideae and Araucarioideae, Australia.

SECTIONS OF CAULERPA.

I. Stolon and erect fronds filiform, without differentiated ramuli.
1. VAUCHERIOIDEAE.

II. Stolon cylindrical and creeping; erect fronds of distinct form.

Stolon naked or with simple or bifid hairs; fronds slender, bearing near the summit whorled ramuli. 2. CHAROIDEAE.

Stolon with hairs or ramuli; frond of a moss-like aspect, surrounded by more or less branching ramuli. 3. BRYOIDEAE.

Stolon naked; fronds elongate in the form of a Zostera leaf, flat or cylindrical, simple or dichotomous; margin entire, without ramuli. 4. ZOSTEROIDEAE.

Stolon naked; fronds flat, margin entire or slightly serrate, little branched, but often producing proliferously from the lamina similar secondary laminae. 5. PHYLLANTOIDEAE.

Stolon naked; fronds flat, deeply dentate, serrate or pinnate, rarely cylindrical, and then surrounded by pinnules several times as long as the diameter of the axis. 6. FILICOIDEAE.

Stolon naked or with scattered ramuli; fronds simple or branched, surrounded by three or more ranks of imbricate spreading or erect ramuli; ramuli sometimes short, usually long, simple, forked, or pinnate. 7. HIPPUROIDEAE.

Stolon covered with woolly hairs or simple ramuli; fronds cylindrical, simple or branched, surrounded by very densely set simple or bifid ramuli. 8. LYCOPODIOIDEAE.

Stolon naked; fronds generally robust, but sometimes slender, fastigiate, cylindrical, surrounded by cylindrical, ovoid or pyramidal ramuli, distichous, tristichous or multiseriate; or sometimes plane and linear with edges entire, dentate or serrate, twisted or not. 9. THUYOIDEAE.

Stolon covered with four-parted scales; fronds resembling an Araucaria, with branches distichous, sub-opposite or alternate, covered with simple or bifid, mucronate ramuli.
10. ARAUCARIOIDEAE.

Stolon naked; frond of a primary naked, simple or dichotomous axis, bearing at its summit simple or dichotomous secondary axes, bearing pinnate ramuli. Pinnules usually unilateral, turned upwards, simple or pinnate, mucronate.
11. PASPALOIDEAE.

Stolon naked; fronds simple or branched, terete or annulate, bearing distichous or multiseriate, ovoid, clavate, cylindrical or linear, sessile or pedicellate ramuli. 12. SEDOIDEAE.

KEY TO THE SPECIES OF CAULERPA.

1. Stolon wanting. 16. *C. ambigua.*
1. Stolon present. 2.
 2. Stolons and fronds filiform, without distinct ramuli. 1. *C. fastigiata.*
 2. Stolons and fronds different in character. 3.
3. Fronds very slender, ramuli whorled, near the summit. 4.
3. Fronds stouter, ramuli not in distinct, distant whorls. 5.
 4. Not over 1 cm. high; stolon and base of fronds hairy. 2. *C. pusilla.*
 4. Up to 5 cm. high; hairs wanting or few. 3. *C. verticillata.*
5. Stolons naked. 6.
5. Stolons with hairs or ramuli. 13.
 6. Fronds flat. 7.
 6. Fronds terete or compressed. 11.
7. Margin entire. 5. *C. prolifera.*
7. Frond pinnate, with linear-lanceolate outline. 8.
7. Frond narrowly linear, more or less twisted, with frequent constrictions. 11. *C. Freycinetii.*
 8. Pinnules flat. 6. *C. crassifolia.*
 8. Pinnules cylindrical or compressed. 9.
9. Pinnules terete, tip obtuse, somewhat clavate. 8. *C. Ashmeadi.*
9. Pinnules mucronate or tapering at tip. 10.
 10. Pinnules narrowed at base and tapering to tip. 7. *C. taxifolia.*
 10. Pinnules at base somewhat larger than the curved and mucronate tip. 9. *C. sertularoides.*
11. Frond with naked primary axis and ramelliferous secondary axes. 13. *C. paspaloides.*
11. Frond without distinction in character between axes of different orders. 12.
 12. Frond beset with ramuli varying from long-clavate to spherical-pedicellate. 14. *C. racemosa.*
 12. Frond with peltate ramuli. 15. *C. peltata.*
 12. Frond more or less angled, with short ramuli of varying forms, the lowest always "rostriform." 12. *C. cupressoides.*
13. Fronds beset with more or less densely branching ramuli. 4. *C. Webbiana.*
13. Fronds beset with very densely set simple or bifid ramuli. 10. *C. Lycopodium.*

1. C. FASTIGIATA Montagne, 1838a, p. 19, Pl. II, fig. 3; Weber, 1898, p. 262, Pl. XX, figs, 1 and 2; Vickers, 1908, p.

25, Pl. XXXVI; P. B.-A., No. 1078. Stolon creeping, naked; fronds ascending, numerous, branching alternate, dichotomous, or opposite; ramuli fastigiate, issuing at rounded angles, cylindrical, long, obtuse, sometimes shorter and slightly clavate. Fla., W. I. *Brazil.*

A Vaucheria-like plant growing in tufts or turfs at low water mark. It would hardly be taken for a *Caulerpa* by one familiar with only the more elaborate forms.

Var. CONFERVOIDES Crouan in Mazé and Schramm, 1870-77, p. 83. Stolon floating, emitting loose, floating fronds, 10 cm. long. Fla., W. I.

Differs from the type only in habit. P. B.-A., No. 1078 seems to belong to this variety rather than to the type.

2. C. PUSILLA (Kütz.) J. G. Agardh, 1872, p. 6; Weber, 1898, p. 266, Pl. XX, fig. 6; Vickers, 1908, p. 25, Pl. XXXVIII. Stolon covered with bifid, hyaline hairs, which attach themselves to the substratum; fronds erect, up to 1 cm. high, at the base surrounded by hyaline hairs, once or twice forked, and bearing near the top two or three successive tufts of whorled, di- or trichotomous, fastigiate, mucronate ramuli. Barbados. *So. America.*

3. C. VERTICILLATA J. G. Agardh, 1848, p. 6; Weber, 1898, p. 267, Pl. XX, figs. 7-10; P. B.-A., No. 665. Stolon creeping, with few hairs; frond repeatedly branched, up to 3-4 cm. high, filiform, bearing at the summit successive series of two or more whorls of ramuli, two to many ramuli in a whorl; ramuli fastigiate or nearly so, sometimes spread out in fan-shape, di- or trichotomous. W. I. *Indian and Pacific Oceans.*

Resembling *C. pusilla*, but a larger plant, and with few or none of the hairs characteristic of the latter.

Forma CHAROIDES (Harv.) Weber, 1898, p. 267; Börgesen, 1907, p. 356, fig. 2. Frond bearing at the summit alternate or opposite, scattered ramuli, not arranged in series of whorls. Cuba, St. Croix. *Pacific.*

4. C. WEBBIANA Montagne, 1840, p. 129; Weber, 1898, p. 269, Pl. XXI, figs. 1-4; P. B.-A., No. 1333. Stolon creeping, covered with branching, hyaline filaments, which adhere to the substratum. Frond ascending, a few cm. high, then recurved and creeping, irregularly branched and surrounded by whorled and imbricated ramuli, usually 4 in a whorl, but varying from 2-6; ramuli cylindrical at the base, repeatedly dichotomous, tips forked or mucronate. Litoral to 50 m. depth. W. I. *Canaries, Mediterranean, Red Sea, Pacific.*

Forma DISTICHA Weber, 1898, p. 270. Ramuli patent, not closely set, in distichous, opposite series on the rachis. St. Croix.

Forma TOMENTELLA (Harv.) Weber, 1898, p. 270; Vickers, 1908, p. 26, Pl. XXXIX. Frond more prostrate than in the type, surrounded by very densely set, spreading ramuli; ramuli in the prostrate part of the frond often prolonged into extended filaments. Barbados. *Pacific.*

5. C. PROLIFERA (Försk.) Lamouroux, 1809a, p. 30; Harvey, 1858, p. 16, Pl. XXXVIII.B; Weber, 1898, p. 278, Pl. XXII, fig. 1; P. B.-A., No. 269. Stolon usually stout, naked, frond plane, linear, obtuse, up to 30 cm. long by 3 cm. wide, rarely divided, margin entire, sometimes slightly undulate; similar fronds often arising proliferously from any point on the original frond; color blackish or olive green. Litoral to 40 m. depth. Fig. 160. N. C. to Fla.; W. I., Yucatan. *Mediterranean.*

Forma OBOVATA J. G. Agardh, 1872, p. 11; Börgesen, 1907, p. 359, fig. 4. Frond shorter and broader, obovate-oblong; same localities as the type.

Forma ZOSTERIFOLIA Börgesen, 1907, p. 359, fig. 6. Fronds narrow-lanceolate, interrupted and abundantly proliferous. In shallow water. St. Croix.

Easily distinguished from all our other species by the flat frond, linear to rounded; growing in sandy places at low water mark and in deeper water.

6. C. CRASSIFOLIA (Ag.) J. G. Agardh, 1872, p. 13; *C. pinnata* Weber, 1898, p. 289, Pl. XXIV, figs. 1-4. Stolon creeping, naked; frond borne on a cylindrical or flattened pedicel, plane, linear-lanceolate, pinnate, up to 10 cm. high; pinnules opposite, plane, at the base as wide or almost as wide as at the middle, erect or patent, tip rounded or mucronate. Litoral to 30 m. depth.

Forma TYPICA (Weber) Börgesen, 1907, p. 363. Pinnules erect, sublinear, not contracted at the base, often acuminate. Fla. from Palm Beach south; W. I. *Tropical seas generally.*

Forma MEXICANA (Sond.) J. G. Agardh, 1872, p. 13, (as variety); Vickers, 1908, p. 26, Pl. XL; P. B.-A., No. 80; *C. mexicana* Harvey, 1858, p. 16, Pl. XXXVII.A. Pinnules erect, slightly contracted at the base, often enlarged at the summit, ending sharply in a mucro; sinus between the pinnules rounded. Same distribution as the type.

Forma **laxior** (Weber) nov. comb.; *C. pinnata* forma *laxior* Weber, 1898, p. 291; *C. crassifolia* var. *mexicana* Alg. Am.-

Bor., No. 170. Pinnules linear, subpatent, mucronate, distinct; sinus not rounded; innovations of frond frequent, borne on long pedicels. Bermuda. *Indian Ocean.*

The forms above described are connected by intermediate stages. The only species likely to be mistaken for *C. crassifolia* is *C. taxifolia*, which has narrower, sickle-shaped, always opposite pinnae. *C. crassifolia* forma **pectinata**, (Kütz.) nov. comb.; *C. pinnata* forma *pectinata* Weber, 1898, p. 291, with narrow frond and short, patent pinnules, has been found at Guyana, and is to be looked for in the more southern West India Islands.

7. C. TAXIFOLIA (Vahl) Agardh, 1822. p. 435; Weber, 1898, p. 292; Vickers, 1908, p. 26, Pl. XLI; P. B.-A., No. 768; *C. asplenioides* Greville, 1853, p. 2, Pl. I, fig. 1. Stolon creeping, naked; frond plane, lanceolate-linear, simple or branched, pinnate, up to 30 cm. long; pinnules sickle-shaped, always opposite, erect, distinctly contracted at the base, long-attenuate at the tip, ending in a short mucro; rachis slender. W. I. Litoral to 30 m. depth.

In some respects intermediate between *C. crassifolia* and *C. sertularioides;* distinguished from both by the opposite, sickle-shaped, narrow pinnules, with contracted base.

8. C. ASHMEADI Harvey, 1858, p. 18, Pl. XXXVIII.A; Weber, 1898, p. 293; Alg. Am.-Bor., No. 36. Stolon stout, creeping, naked; frond simple or branched, up to 25 cm. high, base usually naked, above bearing long, linear, distichous, usually opposite but sometimes alternate pinnules; pinnules cylindrical or compressed, 2-3 cm. long, slightly increasing in diameter from the base to the obtuse summit. Fla. from Jupiter Inlet to Key West; Bermuda, St. Thomas; 20-30 m. depth.

Apparently a rare plant, and probably only from deeper water than most species of the genus.

9. C. SERTULARIOIDES (Gmel.) Howe, 1905a, p. 576; Vickers, 1908, p. 26, Pl. XLII; *C. plumaris* Harvey, 1858, p. 17, Pl. XXXVIII.C; Weber, 1898, p. 294, Pl. XXIV, figs. 5 and 6; Alg. Am.-Bor., No. 169; P. B.-A., Nos. 27, 766. Stolon creeping, naked; frond simple or branched, plane, linear, pinnate, up to 25 cm. high; pinnules opposite or subopposite, cylindrical or compressed, patent, base slightly larger than the curved and mucronate summit; rachis narrow, interval between pinnules as wide as the pinnule. Litoral to 4 m. depth. Fla., W. I. *All tropical seas.*

The appearance of the plant is perfectly described by the specific name *plumaris*, which now, unfortunately, must be given up; only quite aberrant forms are liable to be mistaken for anything else. The four forms described below occur within our limits; forma *brevipes* and forma *longipes* are found everywhere with the type, of which they are merely extreme forms; forma *longiseta* is from Jamaica, forma *Farlowii* from Florida.

Forma BREVIPES (J. Ag.) Svedelius, 1906, p. 114, fig. 7; *C. plumaris* forma *brevipes* Weber, 1898, p. 294. Frond simple, the pinnules extending to the base of the rachis.

Forma **longipes** (Ag.) nov. comb.; *C. plumaris* forma *longipes* Weber, 1898, p. 295. Frond branching, pedicelled, without pinnules for a long distance at the base.

Forma LONGISETA (J. Ag.) Svedelius, 1906, p. 114, fig. 10; *C. plumaris* forma *longiseta* Weber 1898, p. 295. Pinnules fine, long (2 cm.) and close together.

Forma FARLOWII (Weber) Börgesen, 1907, p. 365; *C. plumaris* forma *Farlowii* Weber, 1898, p. 295. Pinnules opposite, alternate, in pairs, or even in several rows.

10. C. LYCOPODIUM Harvey, 1858, p. 19, Pl. XXXVII.B; Weber, 1898, p. 304; *C. lanuginosa* Alg. Am-Bor., No. 37. Stolon and base of fronds covered with woolly hairs; frond up to 10 cm. high; from the point where the hairs cease, covered with simple, bristle-like, imbricate, serrate ramuli, ending sharply in a mucro; branches of the middle of the frond longer than those nearer the base or the summit. Fla., W. I.

Var. DELICATULA (Grun.) Weber, 1898, p. 305, Pl. XXV, fig. 2. Plant very slender, not over 3 cm. high; ramuli filiform, erect, slightly acuminate. Fla. *Pacific, Australia.*

This seems to be merely a dwarf form, but it is of interest as occurring both at Florida and on the opposite side of the globe, while the type occurs only in Florida.

11. C. FREYCINETII Agardh, 1822, p. 446; Weber, 1898, p. 310, Pl. XXV, figs. 4-11; XXVI, figs. 1-6; Phyk. Univ., No. 326. Stolon usually stout, creeping, naked; frond cylindrical or compressed at the base, then plane, linear, foliaceous, often spirally twisted, often alternately constricted and widened, branching always dichotomous, margin dentate, serrate, or entire.

As indicated by this description, this species varies greatly, including forms which, before the intermediate gradations had been seen, passed without question as distinct species. Four varieties are recognized by Mme. Weber, of which we have three, all occurring at Guadeloupe.

Var. TYPICA Weber, 1898, p. 312. Frond usually spirally twisted, frequently narrowed and dilated, margin dentate, teeth as long as or longer than their width.

Forma ANGUSTA Weber, 1898, p. 313. Frond narrow, the interior margin of the spiral entire, the outer dentate; constrictions few.

Forma LATA Weber, 1898, p. 313. Frond broader; both margins dentate; constrictions frequent.

Var. DE BORYANA (Ag.) Weber, 1898, p. 315. Frond simple, cylindrical or compressed, for a long distance before forking; then plane, little or not at all twisted, dentate; teeth distant.

Forma OCCIDENTALIS Weber, 1898, p. 315. Frond not twisted, teeth small, usually wider than long. The typical variety *de Boryana* occurs in the Red Sea; the forma *occidentalis* at Guadeloupe only.

Var. PECTINATA (Mazé and Schramm) Weber, 1898, p. 316; Vickers, 1908, p. 28, Pl. XLIVc. Frond very rarely twisted; constrictions few or many; proliferations often frequent; margin of foliaceous part dentate or pectinate; constrictions naked. W. I.

12. C. CUPRESSOIDES (Vahl) Agardh, 1822, p. 441; Weber, 1898, p. 323, Pls. XVII and XVIII; Harvey, 1858, p. 21, Pl. XXXIX.B; Alg. Am.-Bor., No. 96; P. B.-A., Nos. 79, 575, 765. Stolon usually stout, naked; branches of frond dichotomous, fastigiate or irregular, surrounded by ramuli; ramuli distichous, tristichous, or multiseriate, "sub-navicular" in form, with broad base at the central axis and rounded dorsally; other ramuli ovoid, conical, compressed, or even cylindrical; always mucronate. Litoral to 30 m. depth. Fla., W. I.

An extremely variable species, including many species of earlier authors, species apparently distinct in themselves, but now found to be connected by every gradation. The varieties given below indicate mostly the typical forms of these supposed species, and must be considered merely as showing the range of variation. The best test for the species as a whole is the presence of the "sub-navicular" or "rostriform" ramuli. Even when the ramuli as a whole are of one or more of the numerous forms found in this species, there will always be a few of the characteristic shape near the base of the frond.

Var. TYPICA Weber, 1898, p. 326; Vickers, 1908, p. 27, Pls. XLIV, XLIVb. Frond and its branches with naked base, otherwise surrounded by sub-navicular ramuli, in 3 ranks (rarely in 2, 4 or 5 ranks); length of ramuli up to twice the diameter of the axis. W. I. *India.*

Var. TURNERI Weber, 1898, p. 330. Frond slender, ramuli in 3 or 4 ranks, sub-navicular or conical, small, length hardly equalling the diameter of the axis, appressed, or nearly so. Fla., W. I.

Var. SERRATA (Kütz.) Weber, 1898, p. 331. Frond slender, with elongate branches, dichotomous, alternate, or fascicled; in places naked, but usually near the summit with ramuli in 2 or 3 ranks. Ramuli small, erect or horizontal, sub-navicular, opposite or alternate; length hardly equalling the diameter of the axis. Guadeloupe. *Venezuela.*

Apparently a reduced and depauperate form of vars. *typica* and *Turneri*, due to growth under unfavorable conditions.

Var. MAMMILLOSA (Mont.) Weber, 1898, p. 332; Alg. Am.-Bor., No. 96. Primary axis of the frond naked or covered with mammilliform or obtuse ramuli; branches issuing at acute angles, covered from the base with obovoid or sub-navicular, mucronate, erecto-patent ramuli, in 5 or more ranks; length of ramuli hardly equalling the diameter of the axis.

Forma TYPICA Weber, 1898, p. 332. Base of central axis surrounded by mammilliform ramuli. Fla., W. I. *Australia, So. Pacific.*

Forma NUDA Weber, 1898, p. 332. Base of central axis not surrounded by mammilliform ramuli. Fla., W. I.

Var. ERICIFOLIA (Turner) Weber, 1898, p. 335. Frond surrounded by multiseriate cylindrical ramuli, appressed to the axis; length about the diameter of the axis. W. I.

Var. LYCOPODIUM (Ag.) Weber, 1898, p. 335. Frond tall, generally little branched, ramuli erecto-patent in two ranks, or erect in several ranks, sub-navicular at the base of the frond, cylindrical above, 2-6 times as long as the diameter of the usually slender axis.

Forma ALTERNIFOLIA Weber, 1898, p. 336.* Frond dichoto-

* Börgesen, 1907, p. 368, fig. 17, proposes the name forma *plumarioides* for forma *alternifolia* and forma *elegans* of var. *Lycopodium*, with description as follows: Branches long, rather weak; ramuli in 2 or 3 rows,

mous;, a great part of the ramuli sub-navicular, the rest cylindrical; the former generally in 3 ranks, the latter distichous and opposite, or multiseriate; length up to twice the diameter of the axis. Axis without naked base or with a very short one.

Forma ELEGANS (Crouan) Weber, 1898, p. 336; Vickers, 1908, p. 27, Pl. XLIIIb. Frond dichotomous, ramuli nearly all cylindrical, only a few at the base sub-navicular; length up to 6 times, usually 3 or 4 times the diameter of the axis; distichous and opposite.

Forma INTERMEDIA Weber, 1898, p. 337. Frond very luxuriant, up to 30 cm. high; ramuli all, except those of the base, cylindrical, in two or more series; base naked for a longer or shorter distance.

Forma TYPICA Weber, 1898, p. 337; Vickers, 1908, p. 27, Pl. XLIII. Frond lower than in the preceding forms, simple or branched; ramuli always multiseriate, cylindrical except those at the base, length up to 4 times the diameter of the axis.

All four of these forms at Guadeloupe, among the Mazé and Schramm exsiccatae, under various names; some also at Barbados; forma *alternifolia* at Fla.

Var. DISTICHA Weber, 1898, p. 338. Frond often much branched, base naked; ramuli all except the lowest cylindrical and opposite in two ranks, except occasionally multiseriate near the summit; ramuli erecto-patent, up to twice the diameter of the axis. Fla., W. I.

13. C. PASPALOIDES (Bory) Harvey, 1858, p. 21; Weber, 1898, p. 350, Pl. XXX; Alg. Am.-Bor., No. 38. Stolon robust, up to 4 mm. diam.; frond of a naked stipe (or pedicel), simple or dichotomous, bearing at its summit simple, dichotomous, or palmate branches, covered with ramuli; ramuli in 3 or 4 alternating ranks, subverticillate or inclined to right and left, with bases in contact, imbricate or distinct, pinnate; pinnules inclined to one side, bases adjacent or opposite, simple, forked, or again pinnate, pinnules almost always mucronate.

A species of very characteristic habit, better recognized from specimen or plate than from description; it is limited to Florida, the West Indies, Gulf of Mexico and Carribbean Sea; including three varieties and a number of forms, not clear from each other, but not likely to be mistaken for any other species when one has a clear idea of the type.

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curved upwards, cylindrical, 3-4 times as long as the width of the rachis. He considers it a form of shallow lagoons.

Var. TYPICA Weber, 1898, p. 352. Pedicel of varying height, branches cylindrical or flattened, ramuli pinnate, subverticillate, alternate, and imbricate, sometimes leaving a naked strip along the back of the branch.

Forma PASPALOIDES Weber, 1898, p. 352. Branches subcylindrical; ramuli pinnate; pinnules with bases adjacent, forked or with a single row of secondary pinnules.

Forma PHLEOIDES (Bory) Weber, 1898, p. 353. Branches subcylindrical, ramuli pinnate, pinnules with adjacent bases, with two rows of secondary pinnules.

Forma COMPRESSA Weber, 1898, p. 353. Pedicel very short, 1-2 cm. long; branches 2-3 cm. long, cylindrical, digitate at the summit of the pedicel, surrounded by very dense, imbricate ramuli in many indistinct ranks; ramuli small, plane, with simple or forking, opposite or subopposite, pinnately distichous, patent pinnules.

Forma FLABELLATA Weber, 1898, p. 353. Pedicel up to 11 cm. high; branches simple or branched, flabellately arranged at the summit of the pedicel, flattened, ramuli distinctly inclined to right and left, with bases adjacent, dense, but not as much so as in the preceding forms; pinnules inclined to one side, biseriate, simple or forked.

Var. WURDEMANNI Weber, 1898, p. 353. Pedicel about 8 cm. high; branches 10 cm. or more, with biseriate, subopposite or scattered ramuli, bearing biseriate, simple, unilateral pinnules.

Forma PHYLLOPHLASTON (Murray) Weber, 1898, p. 353; *C. phyllophlaston* Murray, 1891, p. 207, Pl. LIII, figs. 3-6. Pinnules uniseriate.

Var LAXA Weber, 1898, p. 353. Pedicel up to 18 cm. high; branches up to 28 cm.; arising fasciculately at the summit of the pedicel, surrounded by very small, distant, subverticillate ramuli; pinnules small, simple, unilateral.

Var. *Wurdemanni* forma *phyllophlaston* has so far been found only in Yucatan; the other varieties and forms at Florida and the West Indies.

14. C. RACEMOSA (Försk.) J. G. Agardh, 1872, p. 35; Weber, 1898, p. 357, Pl. XXXI, figs. 5-8; XXXII, figs. 1-7; XXXIII; P. B.-A., Nos. 767, 870; *C. clavifera* Harvey, 1858, p. 19; Alg. Am.-Bor., No. 39; P. B.-A., No. 270. Fronds robust or delicate, simple or branched, ramuli distichous, alternate, opposite, multiseriate, or imbricate. Ramuli with rounded or plano-convex summit, enlarging insensibly from the

base to the summit, or, where there is a distinct pedicel, the passage from the pedicel to the summit is not sudden.

One of the most variable of Caulerpas, covering many former species, now arranged under varieties and forms that give no sharp division lines; occurring in one form or another all over the world, mostly in shallow water. Of the 8 varieties given by Mme. Weber, 5 occur with us, also another variety of Börgesen; the following key may be some guide to them.

1. Ramuli usually pyriform-obovoid, with globular or subglobular summit, occasionally laterally flattened; pedicel not over half the total length of the ramulus. . 2.
1. Ramuli claviform with rounded or trumpet-shaped summit; sometimes also cylindrical ramuli present; pedicel often more than half the total length of the ramulus. 3.
2. Fronds with distant, alternate or distichous and subopposite ramuli, usually pyriform with globular summit. Var. *clavifera*.
2. Fronds with multiseriate, imbricate, obovoid or obovoid-compressed ramuli. Var. *uvifera*.
3. Slender and delicate plants. Var. *gracilis*.
3. Stout. 4.
4. Ramuli multiseriate, densely imbricate. 5.
4. Ramuli few or wanting. Var. *Lamourouxii*.
5. Ramuli rather uniformly increasing in size to summit. Var. *laetevirens*.
5. Ramuli suddenly expanded at summit. Var. *occidentalis*.

Var. CLAVIFERA (Turn.) Weber, 1898, p. 361; Vickers, 1908, p. 28, Pl. XLV. Slender, 1-11 cm. high, ramuli generally distant, usually pyriform with globular summit, 1-2.5 mm. diam., and short pedicel. Fla., W. I. *All tropical seas.*

Forma MACROPHYSA (Kütz.) Weber, 1898, p. 361; P. B.-A., No. 870. Ramuli with globular summit 4-5 mm. diam. Jamaica, St. Croix.

Var. UVIFERA (Turn.) J. G. Agardh, 1872, p. 35. Frond cylindrical, simple or branched, with very dense, multiseriate ramuli; ramuli usually obovoid, sometimes globular. *Red Sea.*

Forma CONDENSATA (Kütz.) Weber, 1898, p. 363. Ramuli very dense at the base of the frond, more open near the top. W. I. (forma *condensata* only).

Var. OCCIDENTALIS (J. Ag.) Börgesen, 1907, p. 379, figs. 28 and 29. Ramuli subcylindrical and rather loosely set at the base of the rachis, more clavate and closer above, densely imbricate at the summit; top of ramuli always convex. W. I.

Var. LAETEVIRENS (Mont.) Weber, 1898, p. 366. Fronds robust, up to 12 cm. high, ramuli imbricate, very dense. Ramuli clavate with rounded or hemispherical summit, or sometimes cylindrical.

Forma TYPICA Weber, 1898, p. 366. Ramuli with swollen summit, turned more or less to one side. Fla., W. I.

*Australian, Indian and Pacific Oceans.*

Var. LAMOUROUXII (Turn.) Weber, 1898, p. 368. Frond tall, up to 16 cm., with distichous, alternate, subopposite, or scattered, pyriform or clavate ramuli. Guadeloupe.

*Red Sea, Pacific.*

Var. GRACILIS (Zan.) Weber, 1898, p. 370. Frond slender and elongate, often creeping, with rare cylindrical ramuli, or with a considerable number of small clavate ramuli. Sand Key, Fla.

Possibly only a depauperate form of *C. racemosa.*

15. C. PELTATA (Turn.) Lamouroux, 1809a, Pl. III, fig. 2; Weber, 1898, p. 373, Pl. XXXI, figs. 9-11; XXXII, fig. 8; *C. macrodisca* Phyk. Univ., No. 374. Stolon naked, creeping, branched, robust or delicate; frond delicate, simple or branched, with simple, peltate, scattered ramuli, with a diameter of 3-8 mm., usually 3-5 mm.

Var. TYPICA forma IMBRICATA (Kjellman) Weber, 1898, p. 375. Central axis of the frond surrounded by very dense ramuli. W. I. (Type and forma *imbricata.*)

16. C. AMBIGUA Okamura, 1897, p. 4, Pl. I; Weber, 1898, p. 388; Vickers, 1908, p. 25, Pl. XXXVII; Okamura, Algae Japonicae Exsicc., No. 95. Stolon wanting; frond attached by rhizoids, minute, filiform, solitary, erect, divergently branched, with not very closely set, subdistichous or multiseriate ramuli of diameter about equal to that of the axis, cylindrical or slightly clavate, slightly or not at all contracted at the base. Barbados. *Japan.*

The smallest species of the genus and remarkable for the total absence of the stolon. It is hardly likely that it occurs only at the two widely separated stations now known, but it has probably been overlooked elsewhere on account of its small size.

## Family 6. VAUCHERIACEAE.

Fronds filamentous, cylindrical or with frequent constrictions, with lateral or dichotomous branching; chromatophores small disks, without pyrenoid; asexual reproduction by large, multiciliate zoospores; also by aplanospores and akinetes; sexual reproduction by oogonia and antheridia.

KEY TO THE GENERA OF VAUCHERIACEAE.

1. Filaments cylindrical. 1. VAUCHERIA.
1. Filaments with frequent constrictions. 2. DICHOTOMOSIPHON.

### 1. VAUCHERIA De Candolle, 1805, p. 61.

Fronds filamentous, inarticulate, branches arising laterally but often assuming a dichotomous appearance; forming more or less dense tufted or felty masses, usually attached by colorless rhizoids; numerous small chromatophores without pyrenoids, and with very minute nuclei. Asexual reproduction by very large zoospores, covered with cilia, with a small nucleus corresponding to each pair of cilia; produced in the somewhat clavate ends of branches, partitioned off from the rest of the frond; germinating immediately; by aplanospores produced usually at the ends of short branches, arising similarly to zoospores, but without cilia, germinating only after a longer or shorter period of rest; also in some species by akinetes, the filament breaking up into short portions, each with a thick wall. Sexual reproduction by oogonia and antheridia, of quite variable shape and position; usually on the same filament, but in some species on distinct individuals; oogonium sessile or pedicellate, partitioned off from the frond and producing a large, globose, or subglobose uninucleate oospore; antheridium similarly located and partitioned off from the frond, producing many biciliate spermatozoids, with cilia pointing in opposite directions; when the oospore is formed, the end of the oogonium dissolves, and the spermatozoids enter, fertilizing the oospore, which germinates after a resting period.

A widely distributed genus of unattractive appearing plants, but interesting by their elaborate and varied fructification. Mostly fresh water species, they often extend into brackish water, and some are strictly marine. Sterile plants are quite indeterminable, and fruit is not always easy to find; and in dried material or herbarium specimens the fruit is not in as good condition for study as in most other algae.

KEY TO THE SPECIES OF VAUCHERIA.

1. Antheridia not separated from the frond by an empty cell. 2.
1. Antheridia separated from the frond by an empty cell. PILOBOLOIDEAE. 14.
   2. Antheridia little or not at all curved. TUBULIGERAE. 3.
   2. Antheridia hooked or circinate. CORNICULATAE. 7.
3. Oogonia spherical or nearly so. 4.
3. Oogonia more or less ovoid or oblique. 5.

4. Dioecious; oogonia sessile. 5. *V. dichotoma.*
4. Monoecious; oogonia somewhat stipitate. 2. *V. Thuretii.*
5. Oogonia facing in opposite directions. 4. *V. aversa.*
5. Oogonia single, or several facing one way. 6.
6. Oogonium usually single. 1. *V. Dillwynii.*
6. Oogonia in series of 2-6. 3. *V. ornithocephala.*
7. Oogonia sessile on the main filament or very shortly stipitate. SESSILES. 8.
7. Oogonium on a branch or distinct pedicel, antheridium terminal. RACEMOSAE. 10.
8. Oogonia straight. 8. *V. orthocarpa.*
8. Oogonia oblique. 9.
9. Filaments 33-50 $\mu$ diam. 6. *V. repens.*
9. Filaments 50-85 $\mu$ diam. 7. *V. sessilis.*
10. Oogonium sessile on the branch, or nearly so. 10. *V. terrestris.*
10. Oogonia stipitate. 11.
11. Oogonium usually solitary. 9. *V. hamata.*
11. Oogonia usually 2-6. 12.
12. Pedicels of oogonia and antheridia arising from same point on main filament. 13. *V. Gardneri.*
12. Pedicels of oogonia and antheridia arising near the end of a branch. 13.
13. Branch short; antheridium usually surpassing oogonia. 11. *V. geminata.*
13. Branch long; antheridium not surpassing oogonia. 12. *V. longipes.*
14. Oogonium separated from filament by an empty cell. 18. *V. litorea.*
14. Oogonium not separated from filament by an empty cell. 15.
15. Oogonium with many fecundation tubes. 17. *V. coronata.*
15. Oogonium with only one fecundation tube. 16.
16. Oospore spherical. 17.
16. Oospore lentiform. 14. *V. piloboloides.*
17. Antheridium truncate. 16. *V. intermedia.*
17. Antheridium acute. 15. *V. sphaerospora.*

1. V. DILLWYNII (Web. and Mohr) Agardh, 1810, p. 21; Wittr. and Nordst., Alg. Exsicc., No. 1583; *V. pachyderma* Walz, 1866, p. 146, Pl. XII, figs. 1-6. Terrestrial; filaments 60-100 $\mu$ diam.; oogonia globose or ellipsoid, sometimes subreniform, sessile, rostrate, generally solitary, occasionally two together, about 150 $\mu$ diam.; membrane with fine dots; ripe oospore with brown spots, with thick wall, manifestly lamellate, sometimes up to 7 layers; antheridia saccate, formed at the ends of short, hooked lateral branches, 20 $\mu$ diam., near the single oogonium, or between two approximate oogonia. Me., N. J. *Europe.*

2. V. THURETII Woronin, 1869, p. 157, Pl. II, figs. 30-32; Farlow, 1881, p. 104; P. B.-A., No. 1029. Marine; filaments varying considerably, but reaching 80 $\mu$ diam.; antheridia sessile, ovoid, 50-70 $\mu$ wide, 100-150 $\mu$ long; oogonia sessile or oftener on short lateral branches, obovoid or pyriform, inclined, 200 $\mu$ wide, 250-300 $\mu$ long; oospores 150-180 $\mu$ diam.; aplanospores ovoid, 80 $\times$ 100-120 $\mu$, on short branches at right angles to the filaments. Me. to N. J. *Europe.*

Forming dense dark green patches in muddy ditches by the shore, probably extending farther south than the N. J. station. The filaments of the American plant appear to be usually considerably smaller than those described and figured by Woronin for the European plant, sometimes as low as 30 $\mu$, but otherwise they agree.

3. V. ORNITHOCEPHALA Agardh, 1817, p. 49; P. B.-A., No. 984; *V. sericea* Walz, 1866, p. 150, Pl. XIII, figs. 20 and 21; Wolle, 1887, p. 150, Pl. CXXVII, figs. 12 and 13. Filaments 35-45 $\mu$ diam., oogonia 2-6-seriate, unilateral, obliquely ovoid, 100-150 $\mu$ diam., 1½ diam. long, opening through a broad beak, sessile or very short-pedicelled and in form not unlike a bird's head; oospore nearly globose, about as wide as the oogonium, but not filling it longitudinally, reddish when ripe, with triple membrane; antheridia one or two at one end of a series of oogonia, cylindric to subclavate, 20-25 $\mu$ diam., about 4 diam. long, bent nearly horizontally; zoospores 83-100 $\times$ 90-115 $\mu$, in cylindrical or very slightly clavate sporangia; the cilia much more closely set at the forward end. Occurs mostly in running water. Mass., Pa. *Europe.*

The seriate oogonia with their birds' heads facing the antheridium at one end, make a pretty good mark for distinguishing this from species hitherto reported in America, but the same characters are found in the European *V. polysperma* Hassall, which very likely will sometime be found here. It is more slender throughout, the filaments 22-33 $\mu$, the oogonia 60-65 $\mu$ diam., and more nearly erect; zoospores 66-88 $\mu$ diam.; antheridium always single.

4. V. AVERSA Hassall, 1843b, p. 429; 1845, p. 54, Pl. VI, fig. 5; Walz, 1866, p. 151, Pl. XIII, figs. 25 and 26; Pl. XIV, fig. 27; Wolle, 1887, p. 149, Pl. CXXVII, figs. 5-8; P. B.-A., No. 475. Filaments 60-100 $\mu$ diam.; oogonia obliquely ovoid, sessile or shortly stipitate, two, rarely more in a series, the beaks usually in opposite directions, mostly erect, 125-250 $\mu$;

oospore globose or ovoid, with triple membrane, 75-100 $\mu$ diam., not filling the oogonium; antheridia cylindric or subclavate, 30-40 $\mu$ diam., erect, more or less incurved, on each side of the series of oogonia. In ponds and ditches. Mass., Conn., Neb., Cal. *Europe.*

The distinguishing mark for this species is found in the oogonia facing in opposite directions.

5. V. DICHOTOMA (L.) Agardh, 1817, p. 47; Walz, 1866, p. 152, Pl. XIV, figs. 28-33; Wolle, 1887, p. 149, Pl. CXXVI, figs. 1-7; Wittr. and Nordst., Alg. Exsicc., Nos. 337, 338. Dioecious, filaments 135-200 $\mu$ diam., oogonia sessile, 300-400 $\mu$ diam., globose or ovoid-globose, distant or 2-6 approximate; ripe oospore with triple membrane, brown spotted; antheridia erect, ovoid, 90-150 $\times$ 150-250 $\mu$. In ponds and ditches. W. I. *Europe.*

Recorded by Wolle without definite locality. *V. Pilus* Wolle, 1887, p. 153, Pl. CXXVII, figs. 1-4, from Vt., may be a form of this species.

6. V. REPENS Hassall, 1843b, p. 430; 1845, p. 52, Pl. VI, fig. 7; Götz, 1897, p. 110, figs. 14-16. Filaments 33-50 $\mu$ diam.; oogonia single, rarely two, sessile, obliquely ovoid, 70-80 $\times$ 55-80 $\mu$, ending in a short beak, usually horizontal; oospore quite filling the oogonium, grayish, coarse grained, with triple membrane and one or more brown spots; antheridium close to the oogonium, circinate, on a straight or curved pedicel; zoospores 80-130 $\times$ 75-120 $\mu$, formed in nearly cylindrical sporangia; cilia uniformly distributed. On moist ground or submerged. Cal. *Europe.*

7. V. SESSILIS (Vauch.) De Candolle, 1805, p. 63; Kützing, 1856, Pl. LIX, fig. 2; Wolle, 1887, p. 151, Pl. CXXVII, figs. 9-11; Götz, 1897, p. 111, figs. 17-22; P. B.-A., No. 228. Filaments 50-85 $\mu$ diam.; oogonia usually two, sometimes single, sessile, ovoid or oblong-ovoid, 70-85 $\times$ 75-100 $\mu$, more or less oblique, with short beak; antheridium between the oogonia or beside the single oogonium, on a short pedicel, straight, hooked or circinate; ripe oospore dark-spotted, with triple membrane, filling the oogonium; zoosporangia ovoid-clavate, terminal on a branch which is however sometimes so short that the sporangium appears sessile; zoospores 110-145 $\times$ 110-125 $\mu$, with cilia evenly distributed. Me., Mass., R. I., Conn., N. J., Neb., Alaska to Cal. *Europe.*

A common species in brooks and ditches.

8. V. ORTHOCARPA Reinsch, 1887, p. 189, Pl. VIII; *V. cla-*

*vata* Götz, 1897, p. 114, figs. 23-28; an *Ectosperma clavata* Vaucher? Filaments 77-110 $\mu$ diam.; oogonia one or two, sessile, 55-75×80-110 $\mu$, narrowly ovoid, erect, with a short and broad vertical beak; oospore of same shape, 50-65×65-90 $\mu$ with a red central spot and triple membrane; antheridium solitary beside a single oogonium or between two oogonia, circinate, on a straight or recurved pedicel; zoospores 125-150×135-175 $\mu$, in broadly clavate sporangia; cilia uniformly distributed. In ponds and ditches. Cal. *Europe.*

The three species, *V. repens*, *V. sessilis* and *V. orthocarpa* are certainly closely related, but Götz, who has studied them more than any other observer, considers them distinct. Beside the differences in dimensions of filaments and dimensions and shape of oogonia, he notes physiological characters, which it is not practicable to give here in detail. As far as Vaucher's description of *Ectosperma clavata* goes, it would seem to apply to any zoosporiferous *Vaucheria;* Götz does not state why he identifies *E. clavata* with *V. orthocarpa* Reinsch, except that the sexual organs in his plant agree with Reinsch's description and plate; but Vaucher knew the zoospores only.

9. V. HAMATA (Vauch.) De Candolle, 1805, p. 63; Walz, 1866, p. 148, Pl. XII, figs. 12-16; Wolle, 1887, p. 152, Pl. CXXVIII, figs. 8-10. Filaments 40-60 $\mu$ diam., oogonia solitary, 75-90×60-75 $\mu$, ovoid to convex-concave, borne on the shorter division of an apparently forking branch; the longer division recurved, bearing the hooked or circinate antheridium; or an oogonium on each division, the antheridium between; antheridium in a plane at an angle to that of the oogonium; oospore closely filling the oogonium, with quadruple membrane and a dark brown or blackish central spot; the membrane of the oogonium falling with the oospore, but not gelatinizing; aplanospores formed in terminal, somewhat clavate sporangia, when ripe ejected from the latter. On moist ground or submerged. Washn., Cal. *Europe.*

10. V. TERRESTRIS (Vauch.) De Candolle, 1805, p. 62; Walz, 1866, p. 149, Pl. XIII, figs. 18 and 19; Wolle, 1887, p. 153, Pl. CXXIX, figs. 1-8; P. B.-A., No. 78. Filaments 50-80 $\mu$ diam.; oogonium usually solitary, 85-125×60-100 $\mu$, lateral on a short branch, on the summit of which is the curved or circinate antheridium, about 20 $\mu$ diam.; oospore globose to plano-convex, with quadruple membrane and numerous brownish spots; the membrane of the oogonium remaining attached to the oospore and falling with it, gelatinizing and ultimately

disappearing. Though the antheridium is really terminal, it is often pushed aside by the oogonium, and appears to be lateral, below the oogonium. On moist ground or submerged, common. Greenland, Mass., Neb., Cal. *Europe.*

There is considerable resemblance between *V. terrestris* and *V. hamata*, but in the former the fruiting branch is short, the oogonium practically sessile on the pedicel of the antheridium; in the latter the fruiting branch is usually longer and the oogonium and the antheridium are on distinct pedicels, appearing as if the branch had forked; the manner of disappearance of the oogonium membrane is different; aplanospores are not known in *V. terrestris*, though it is the commoner species.

11. V. GEMINATA (Vauch.) De Candolle, 1805, p. 62; Walz, 1866, p. 147, Pl. XII, figs. 7-11; Wolle, 1887, p. 151, Pl. CXXVIII, figs. 1-3; P. B.-A., No. 1287. Filaments 50-100 $\mu$ diam.; oogonia 2, 70-90$\times$60-75 $\mu$, ellipsoid-hemispherical to convex-concave, shortly stipitate near the end of a short branch; the antheridium between them, cylindrical, hooked or circinate; ripe oospore brown-spotted with triple membrane, filling the oogonium; aplanosporangia either on the same frond as the oogonia or on separate individuals, aplanospores 120-200$\times$120-190 $\mu$, formed in ovoid sporangia usually terminating short, lateral branches, freed by the dissolution of the membrane; akinetes formed by the breaking up of portions of the filaments into short, thick-walled cells, whose development varies considerably, according to circumstances. Common in quiet or slowly running water. Greenland, Me., Mass., N. J., Neb., Cal. *Europe.*

Var. RACEMOSA (Vauch.) Walz, 1866, p. 147; P. B.-A, No. 268. Oogonia 3-many, smaller than in the type, corymbosely arranged about the antheridium. Vt., Mass., N. J., Neb., Washn., Cal. *Europe.*

The variety differs from the type only by the greater number of oogonia, and there is no sharp division; plants representative of each can often be found in the same tuft; the variety seems to be more abundant than the type.*

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*Götz, 1897, p. 124, includes under *V. racemosa* what is above included under both *V. geminata* and *var. racemosa*; and at p. 126 applies the name *V. geminata* to what appears to be quite a different plant, and to judge by the descriptions and figures a good species; but why it should bear the name of *V. geminata* is not so clear. His fig. 45, shows a quite regular ovoid spore; Vaucher says that the spores of *Ectosperma geminata* "au lieu d'être arrondies, representent une portion de sphère forte-

12. V. LONGIPES Collins, 1907, p. 201, Pl. LXXVI, fig. 1. Filaments 80-90 $\mu$ diam., oogonia and antheridia borne at the end of a branch one to several mm. long, 30-40 $\mu$ diam.; antheridium terminal, cylindrical or slightly tapering, hooked or circinate; oogonia 70-85 $\times$ 35-40 $\mu$, ovoid, slightly oblique, 2-4, on pedicels 20-30 $\mu$ diam., 100-150 $\mu$ long, arising a little below the antheridium, and usually surpassing it. In brooks and pools. Cal.

Somewhat resembling *V. geminata*, but distinct by the very long fruiting branches, at right angles to the filaments, as well as by the longer pedicels of the oogonia.

13. V. GARDNERI Collins, 1907. p. 201, Pl. LXXVI, figs. 2 and 3; P. B.-A., No. 1288. Filaments 50-70 $\mu$ diam., sparingly branched, branches mostly at right angles; antheridia and oogonia borne on pedicels of about the same size, 60-100 $\mu$ long, 15-20 $\mu$ diam., arising from the same point on the filament; antheridium solitary, terminal on the central, vertical pedicel, less commonly 2 or 3 on independent pedicels, hooked or circinate, tapering to 10 $\mu$ diam.; oogonia 2-4, occasionally more, 85-95 $\times$ 60-70 $\mu$, quite oblique, often concave on the inner side, on opposite sides of the antheridium or encircling it, their pedicels at about 45 degrees to the filament; usually surpassing the antheridium. In brooks and pools. Fig. 153. Cal.

In general arrangement like *V. longipes*, but the pedicels bearing the organs of fructification are placed directly on the filament, radiating from one spot; the oogonia are much more oblique, often concave inside.

Forma TENUIS Collins, 1907, p. 201. Filaments 30-40 $\mu$ diam.; antheridia often more numerous than the oogonia; oogonia sometimes single. With the type. Cal.

When in this species two oogonia occur with one antheridium, there is a certain resemblance to *V. geminata*; but the slender radiate pedicels make it amply distinct; the forms with many oogonia and antheridia are quite unlike anything else. The largest number of pedicels observed in a group is 12, four bearing antheridia, eight oogonia.

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ment échancrée à l'interieur." Figures 43 and 44, *V. racemosa*, have spores quite like this description. The filaments of *E. geminata*, according to Vaucher, are about half the size of those of *E. sessilis*; while according to Götz the two species are of about the same size, *V. geminata* slightly larger. There is no indication in the descriptions and figures of Vaucher and Hassall of the lateral prolongations of the antheridium characteristic of Götz' plant. If the latter were to be identified with any of Vaucher's species, *E. cruciata* seems more probable than *E. geminata*, except that it is said to be quite small in all of its dimensions.

14. V. PILOBOLOIDES Thuret in Le Jolis, 1863, p. 65, Pl. I, figs. 4 and 5; Woronin, 1869, p. 153, Pl. II, figs. 18-29; P. B.-A., No. 476. Marine; filaments usually 40-60 $\mu$ diam., sometimes 80 $\mu$; antheridium terminal, separated from the filament by an empty cell, cylindrical, acute, with one or two lateral, conical projections; oogonium terminal, usually on a short branch near the antheridium, clavate with a spherical summit, up to 200 $\mu$ diam.; oospore lenticular with thin membrane, $150 \times 80$-$100$ $\mu$; aplanospores $250 \times 80$ $\mu$, formed at the ends of the branches, expelled from the sporangium at maturity. Muddy and sandy places, below low water mark. Conn.

Var. COMPACTA Collins, 1900, p. 13; P. B.-A., No. 477. Tufts very densely matted; oospores usually spherical, occasionally lenticular; oogonia and antheridia scattered without definite relation to each other. Salt marshes, on mud near high water mark. Mass.

The dense, plush-like coatings of this variety are indistinguishable from *V. Thuretii*, that grows in similar locations; but the fructification is quite distinct.

15. V. SPHAEROSPORA Nordstedt, 1878a, p. 177, Pl. II, figs. 7 and 8; Phyk. Univ., No. 282. Marine; filaments 25-60 $\mu$ diam., loosely tufted; antheridium at the somewhat swollen end of a branch, generally slightly curved, acuminate, bearing just below the summit two conical, subopposite processes; oogonium below on the same branch, separated by an empty cell, globose or obovoid-globose, 105-135 $\mu$ diam.; oospore green, with thin membrane, 85-125 $\mu$ diam., not filling the oogonium. Greenland. *Northern Europe.*

16. V. INTERMEDIA Nordstedt, 1879, p. 179, Pl. I, figs. 10-16; Wittr. & Nordst., Alg. Exsicc., No. 334. Marine; filaments 35-65 $\mu$ diam.; oogonia subsessile or shortly pedicelled, globose or ovoid-globose, 90-130 $\mu$ long, 95-115 $\mu$ wide, with one short and broad tube; antheridium single or often two, 20-30 $\mu$ diam., usually straight with rounded, truncate apex, and 2-4 very short, lateral tubes; oospore globose, with thin membrane, 85-120 $\mu$ diam., almost filling the oogonium. Greenland. *Northern Europe.*

17. V. CORONATA Nordstedt, 1879, p. 177; Pl. I, figs. 1-9; Wittr. and Nordst., Alg. Exsicc., No. 1022. Marine; filaments 48-70 $\mu$ diam.; oogonia solitary, subsessile, borne on the branches bearing the antheridia, more rarely on the main filaments, obovoid or obliquely ovoid, 125-145 $\mu$ long, 145-180 $\mu$ wide, bearing at the top a circle of 3-6 tubes for the entrance of the spermatozoids; oospore globose or subglobose, $115$-$135 \times 115$-

145 $\mu$, not quite filling the oogonium; ripe oospore with occasional brown spots, and thick, minutely pitted membrane; antheridium straight with rounded apex, at the end of the branch bearing the oogonium, single, or oftener two, 30-40 $\mu$ diam., separated from the branch by an empty cell; with one apical tube. Greenland. *Northern Europe.*

18. V. LITOREA Agardh, 1821, p. 463; Nordstedt, 1879, p. 180, Pl. II, figs. 1-6; Farlow, 1881, p. 105; P. B.-A., No. 166. Marine, dioecious; filaments 70-95 $\mu$ diam.; antheridium at the end of a longer or shorter branch, supported by an empty cell, cylindrical, rather obtuse, with 2-4 short, lateral projections; oogonium at the extremity of a reflexed branch, clavate or obovoid, about 200 $\mu$ wide and 300-400 $\mu$ long; separated from the filament by a short, empty cell; oospore subglobose, with thick membrane, 180-250 $\mu$ diam., occupying the upper part of the oogonium. Mass. to N. J. *Europe.*

A coarse, dingy plant, with long filaments forming loose tufts, on mud and gravel at low water mark.*

DICHOTOMOSIPHON Ernst, 1902, p. 115.

Frond filamentous, inarticulate, multinucleate, with disk-shaped chromatophores without pyrenoid; filaments di-polychotomous, attached below by slender, colorless rhizoids; branches constricted at base to about half the diameter; similar constrictions formed at intervals between the branchings; membrane thickened at the constrictions, often becoming brown; starch accumulation in large quantities throughout the frond. Sexual reproduction by terminal oogonia and antheridia; oospore globose, with triple membrane, germinating after a resting period. Asexual reproduction by akinetes, in the form of tubercular swellings at the ends of the branches, or oftener on special lateral branches, germinating after a resting period.

This genus differs from *Vaucheria* by the true dichotomous branching, the peculiar asexual reproduction, the corymbose arrangement of the sexual organs, the presence of starch in large quantity, and the tendency to articulation shown by the constrictions. While the sexual fructification, except as to the position of the organs, is the same as in *Vaucheria*, the vegetative characters are curiously like those of some of the marine Codiaceae; when a *Udotea*, for instance, is decalcified, the fila-

** V. velutina* Wolle, 1887, p. 153, is given merely from older references. According to Farlow, 1881, p. 105, a specimen from J. W. Bailey, marked by him *V. velutina*, is probably *V. Thuretii* Woronin.

ments are in many cases like those of *Dichotomosiphon*. As far as vegetative structure is concerned, there would seem to be a definite phylogenetic series from *Dichotomosiphon* through *Avrainvillea*, *Penicillus*, *Rhipocephalus* and *Udotea* to *Halimeda*; but while the reproductive organs of *Dichotomosiphon* are of high rank, those of *Halimeda* are much lower and of a different type, and practically nothing is known as to the reproduction of the intermediate genera. If any of these genera should ever be found to have fructification resembling that of *Dichotomosiphon*, or if sporangia like those of *Halimeda* were found in *D. pusillus*, the latter would have to be considered as the primary form of the Codiaceae or at least of the Udotoideae, from which the other forms had developed. There is one well known fresh water species, to which a marine form is now doubtfully added.

KEY TO THE SPECIES OF DICHOTOMOSIPHON.

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| 1. Filaments 40-100 $\mu$ diam.; fresh water. | 1. *D. tuberosus.* |
| 1. Filaments 10-30 $\mu$ diam.; marine. | 2. *D. pusillus.* |

1. D. TUBEROSUS (A. Braun) Ernst, 1902, p. 115, Pls. VI-X; *Vaucheria tuberosa* A. Braun in Kützing, 1856, p. 23, Pl. LXV; Wolle, 1887, p. 154, Pl. CXXIX, figs. 9-14, Pl. CXXX; P. B.-A., No. 764. Fronds 2-10 cm. long, 40-110 $\mu$ diam., usually 70-95 $\mu$; akinetes straight and elongate or clavate and curved, 0.5-5 mm. long, 200-400 $\mu$ diam.; antheridia and oogonia corymbosely arranged at the ends of the ultimate divisions; antheridia cylindrical or clavate, more or less incurved, 130-170 $\times$ 35-50 $\mu$; oogonia globose, 290-320 $\mu$ diam.; oospore globose, dark green, 250-280 $\mu$ diam. Fig. 158. Ont., Pa., Mich., Ill., Ga., Texas. *Europe.*

This species occurs in similar localities to *Vaucheria*; it appears to be more common in America than in Europe, where it is reported only from Switzerland. In P. B.-A., No. 764, the oogonia are large enough to be seen by the naked eye, but are erroneously referred to in the label as "tuber-like swellings." Wolle's varieties *intermedia* and *minor* are merely smaller, sterile forms.

2. D. **pusillus** n. sp. Filamentis prostratis, irregularibus, 10-30 $\mu$ diam., hinc et illinc constrictis, di- trichotomis; ramis basi fortiter constrictis, apice et sub dichotomiis saepe claviformiter distentis; ramis lateralibus brevibus et simplicibus frequentis, sine ordine egredientibus, raro oppositis.

Filaments prostrate, irregular, 10-30 $\mu$ diam., here and there constricted, di- trichotomous; branches strongly constricted at the base, often clavately swollen at the end or when forking; lateral branches also common, usually short and simple, occasionally opposite. In shallow water, in company with *Bostrychia tenella* (Vahl) J. Ag., *Lyngbya confervoides* Ag., etc. Marine. W. I.

Nothing being known as to its reproduction, the inclusion of this plant in *Dichotomosiphon* is only provisional; in vegetative characters the correspondence is marked. It forms rather dense mats on the surface of the *Bostrychia*, and appears to be common in Jamaica and other West India islands. The filaments in the under part of the mats are colorless as in *Vaucheria;* at first glance one is reminded of the simpler forms of *Udotea minima* Ernst, 1904, Pl. VII, figs. 1-10, but though part of the plant is colorless, part bright green, there is no distinction in form between the two as in the *Udotea*, and both seem to remain prostrate. In a few instances there have been noticed short simple branches in three or four opposite, approximate pairs, with triangular outline, like the tip of a branch of *Bryopsis plumosa*, but this may have been accidental; there was nothing to indicate that it was a distinct erect growth. The constrictions at the base of the branches are strongly marked, with stratified thickening inside the wall; the constrictions in the filaments may be distant, or they may be scarcely more than one diameter apart, when the frond appears markedly moniliform.

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The following species was omitted from the proper place, p. 183 of this work.

ULOTHRIX SCUTATA Jónsson, 1904, p. 57, figs. 8 and 9. Filaments attached by a basal disk, with even or lobed margin; lower cells 5-6 $\mu$ diam., 1-3 diam. long; upper cells 9-16 $\mu$ diam., $\frac{1}{3}$-1 diam. long; chromatophore zonate, not occupying the whole length of the cell, with one pyrenoid. Filaments with more or less distinct constrictions, at intervals of about 4 cells. Greenland.

The basal disk characteristic of this species is usually separated from the rest of the basal cell by a sharp constriction; in addition to the disk, the filaments are often attached by rhizoids to the substratum, fronds of *Spongomorpha*.

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## EXPLANATION OF PLATES.

### PLATE I.

1. Botrydiopsis eriensis, after Snow. 1000 × 1.
2. Ophiocytium majus, after Nägeli. 500 × 1.
3. Chlorobotrys regularis, after West. 350 × 1.
4. Conferva bombycina, after West. 750 × 1.
5. Botrydium granulatum, after West. 15 × 1.
6. Characiopsis minuta, after West. 350 × 1.
7. Zygnema stellinum, with spores, after West. 300 × 1.
8. Spirogyra protecta, with spores, after Petit. 250 × 1.

9a. Debarya glyptosperma, conjugating; 9b, with ripe spores; after De Bary. 250 × 1.

10. Zygogonium ericetorum, conjugating, after De Bary. 400 × 1.
11. Gonatonema ventricosum, with spores, afterWest. 800 × 1.

### PLATE II.

12. Mougeotia viridis, with spores, after De Bary. 1000 × 1.
13. Chlamydomonas angulosa, after Dill. 1000 × 1.
14. Haematococcus pluvialis, after Hazen. 700 × 1.
15. Chlorogonium euchlorum, after Stein. 1000 × 1.
16. Gonium pectorale, after Migula. 600 × 1.
17. Pandorina Morum, after Pringsheim. 700 × 1.
18. Pleodorina illinoisensis, after Kofoid. 500 × 1.

### PLATE III.

19. Platydorina caudata, face view, after Kofoid. 500 × 1.
20. Platydorina caudata, side view, after Kofoid. 300 × 1.
21. Eudorina elegans, after Göbel. 300 × 1.
22. Volvox globator, after Oltmanns. 300 × 1.
23. Palmella miniata, after Nägeli. 400 × 1.

### PLATE IV.

24. Botryococcus Braunii, colony dividing, after West. 600 × 1.
25. Ineffigiata neglecta, after West. 700 × 1.
26. Tetraspora lubrica, after Nägeli. 400 × 1.

27. Apiocystis Brauniana, after Nägeli. 250 × 1.
28. Palmodactylon varium, young colony, after West. 125 × 1.
29. Prasinocladus subsalsus, after Davis. 600 × 1.
30. Collinsiella tuberculata, after Setchell. 200 × 1.
31. Chlorococcum humicola, after Nägeli. 300 × 1.
32a. Trochiscia reticularis, after West. 400 × 1.
32b. Trochiscia hirta, after West. 300 × 1.
33. Chlorochytrium Lemnae, cells in different stages, in tissue of Lemna, after Klebs. 200 × 1.
34. Rhodochytrium Spilanthidis, irregularly shaped cell, after Lagerheim. 200 × 1.
35. Chlorocystis Cohnii, on Enteromorpha, after Moore. 1000 × 1.

PLATE V.

36. Characium gracilipes, after Lambert. 500 × 1.
37. Codiolum gregarium, after A. Braun. 100 × 1.
38a. Protosiphon botryoides, vegetative, after Klebs. 50 × 1.
38b. Protosiphon botryoides, with aplanospores, after Klebs. 100 × 1.
39. Eremosphaera viridis, section of cell, after Moore. 200 × 1.
40. Excentrosphaera viridis, section of cell, after Moore. 1000 × 1.
41. Zoochlorella conductrix, in Hydra viridis, after Beyerinck. 600 × 1.
42. Rhaphidium falcatum var. fusiforme, group of individuals, after Nägeli. 300 × 1.
43. Palmellococcus miniatus, with aplanospores, after Chodat. 800 × 1.
44. Oocystis solitaria, after West. 800 × 1.
45. Chodatella citriformis, after Snow. 1000 × 1.
46. Nephrocytium Agardhianum, mother and daughter cells, after Nägeli. 1000 × 1.
47. Tetraedron trigonum, front and side views, after Nägeli. 800 × 1.
48. Cerasterias raphidioides, after Reinsch. 1000 × 1.

PLATE VI.

49. Thamniastrum cruciatum, after Reinsch. 500 × 1.

50. Schizochlamys gelatinosa, recently divided cell, after West. 500 × 1.
51. Elakatothrix americana, mother and daughter cells, after Snow. 800 × 1.
52. Hormotila mucigena, after West. 500 × 1.
53. Scenedesmus obliquus, after Nägeli. 500 × 1.
54. Crucigenia rectangularis, after West. 600 × 1.
55. Selenastrum minutum, after Nägeli. 1000 × 1.
56. Kirchneriella lunaris, after Bohlin. 800 × 1.
57. Coelastrum cambricum, after West. 800 × 1.
58. Sorastrum spinulosum, after Nägeli. 500 × 1.
59. Dictyosphaerium Ehrenbergianum, after Nägeli. 600 × 1.
60. Dimorphococcus cordatus, after Wolle. 500 × 1.
61. Dictyocystis Hitchcockii, after Wolle. 600 × 1.
62. Hydrodictyon reticulatum, young colony in mother cell, after Klebs. 100 × 1.
63. Pediastrum Boryanum, after Nägeli. 800 × 1.
64. Ulothrix zonata, vegetative, after Hazen. 300 × 1.
65. Hormospora purpurea, after Wolle. 300 × 1.

## PLATE VII.

66. Uronema confervicola, after Lagerheim. 800 × 1.
67. Schizomeris Leibleinii, after Hansgirg. 60 × 1.
68. Microspora tumidula, akinetes in formation, after Hazen. 500 × 1.
69. Stichococcus bacillaris, after Nägeli. 800 × 1.
70. Enteromorpha erecta, surface view, after Collins. 200 × 1.
71. Ilea fulvescens, surface view, after Collins. 200 × 1.
72. Monostroma fuscum, cross section, after Collins. 200 × 1.
73. Protoderma viride, surface view, after Rabenhorst. 600 × 1.
74. Radiofilum apiculatum, surface view, after Bohlin. 800 × 1
75. Ulva Lactuca, cross section, after Thuret. 300 × 1.
76. Schizogonium crenulatum, surface view, after Gay. 1000 × 1.
77. Prasiola crispa, mature frond, after Oltmanns. 100 × 1.

78. Gayella polyrhiza, multiseriate stage, after Rosenvinge. 500 × 1.
79. Gayella polyrhiza, with rhizoids, after Rosenvinge. 500 × 1.
80. Cylindrocapsa geminella, with oogonia, after Hansgirg. 300 × 1.

PLATE VIII.

81. Oedogonium fragile, with oogonia and antheridia, after Wittrock. 400 × 1.
82. Bulbochaete intermedia, with oogonia and dwarf males, after Wittrock. 300 × 1.
83. Microthamnion Kuetzingianum, after Hazen. 700 × 1.
84. Stigeoclonium lubricum, after Hazen, 400 × 1.
85. Chaetophora elegans, after Hazen. 400 × 1.
86. Chlorotylium cataractarum, branching filament, after Rabenhorst. 400 × 1.
87. Pseudendoclonium submarinum, after Wille. 1000 × 1.
88. Endoclonium Moebiusianum, portion of disk, after Möbius. 600 × 1.

PLATE IX.

89. Draparnaldia glomerata, after Hazen. 300 × 1.
90. Pilinia Morsei, after Collins. 400 × 1.
91. Gongrosira deBaryana, after Rabenhorst. 300 × 1.
92. Ochlochaete ferox, after Huber. 300 × 1.
93. Dermatophyton radians, on and in shell of turtle, after Potter. 500 × 1.
94. Epicladia Flustrae, after Reinke. 400 × 1.

PLATE X.

95. Pringsheimia scutata, mature frond with spores, after Reinke. 600 × 1.
96. Chaetopeltis americana, portion of disk, after Snow. 400 × 1.
97. Arthrochaete penetrans, after Rosenvinge. 500 × 1.
98. Chaetobolus gibbus, after Rosenvinge. 300 × 1.
99. Diplochaete solitaria, by Lambert. 400 × 1.
100. Endoderma Wittrockii, after Hazen. 400 × 1.
101. Acrochaete repens, with sporangia, after Pringsheim. 500 × 1.

PLATE XI.

102. Ulvella lens, after Huber. 300 × 1.
103. Gloeocystis gigas, after West. 500 × 1.
104. Chaetosphaeridium Pringsheimii, after Klebahn. 800 × 1.
105. Urococcus Foslieanus, after Foslie. 800 × 1.
106. Pleurococcus vulgaris, after West. 1000 × 1.
107. Palmodictyon viride, after West. 400 × 1.
108. Bolbocoleon piliferum, with sporangia, after Hauck. 600 × 1.
109. Gloeotaenium Loitlesbergerianum, after Stockmayer. 500 × 1.

PLATE XII.

110. Coleochaete divergens, with oogonia, after Pringsheim. 200 × 1.
111. Tellamia contorta, cross section, after Batters. 200 × 1.
112. Tellamia contorta, surface view, after Batters. 300 × 1.
113. Pithophora oedogonia, with akinetes, after Wittrock. 40 × 1.
114. Nylandera tentaculata, after Hariot. 300 × 1.
115. Chaetomorpha aerea, basal and upper portions, after Hauck. 40 × 1.
116. Herposteiron confervicola, after Hazen. 800 × 1.
117. Trentepohlia Wainoi, after Hariot. 250 × 1.
118. Dactylothece confluens, after Nägeli. 1,000 × 1.
119. Rhizoclonium hieroglyphicum, after Stockmayer. 300 × 1.

PLATE XIII.

120. Pseudodictyon geniculatum, surface view, after Gardner. 500 × 1.
121. Endophyton ramosum, section of host with endophyte, after Gardner. 300 × 1.
122. Gloiococcus mucosus, after West. 400 × 1.
123. Cephaleuros Mycoidea, after Karsten. 200 × 1.
124. Cladophora glomerata, after West. 100 × 1.

PLATE XIV.

125. Anadyomene stellata, after Oltmanns. 10 × 1.
126. Spongomorpha spinescens, after Kjellman. 40 × 1.
127. Cystodictyon pavonium, by Lambert. 10 × 1.

128. Boodlea compacta, after Brand. 40 × 1.
129. Cladophoropsis membranaceus, after Börgesen. 20 × 1.
130. Halicystis ovalis, after Saunders. 2 × 1.

PLATE XV.

131. Acetabularia crenulata, group of individuals, after Harvey. 2 × 1.
132. Microdictyon Agardhianum, after Montagne. 20 × 1.
133. Hormiscia penicilliformis, filament, after Areschoug, 200 × 1. Zoospore, after Areschoug. 1000 × 1.
134. Struvea anastomosans, after Harvey. 3 × 1.
135. Gomotia polyrhiza, with sporangium, after Bornet and Flahault. 300 × 1.
136. Chamaedoris annulata, after Harvey. 1 × 1.
137. Dictyosphaeria favulosa, group of individuals, after Harvey. 10 × 1.
138. Valonia utricularis, after Schmitz. 10×1.

PLATE XVI.

139. Siphonocladus rigidus, after Howe. 20 × 1.
140. Chalmasia antillarum, stipe and disk, 5 × 1; details of base of disk, 20 and 40 × 1, after Solms.
141. Sphaeroplea annulina, with oospores, after Hansgirg. 200 × 1.
142. Dasycladus claveformis, after Hauck. 1 × 1.
143. Neomeris annulata, group of individuals, after Cramer. 1 × 1.
144. Codium tomentosum, utricle and sporangium, after Thuret. 75 × 1.
145. Batophora Oerstedi, group of individuals, after Harvey. 1 × 1.
146. Cymopolia barbata, after Harvey. 1 × 1.
147. Avrainvillea levis, after Howe. 1 × 1.
148. Acicularia Schenckii, disk from above, 5 × 1; contents of sporangium, 10 × 1, after Börgesen.

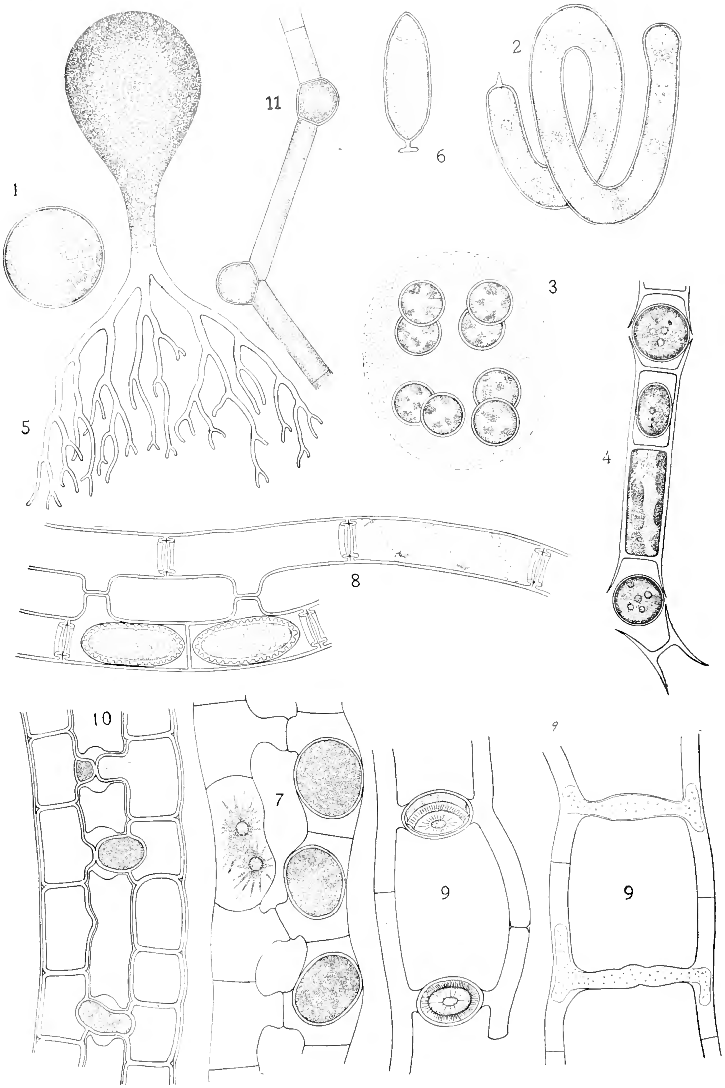
PLATE XVII.

149. Penicillus capitatus, after Harvey. 1 × 1.
150. Rhipocephalus Phoenix, after Harvey. 2 × 1.

151. Cladocephalus luteo-fuscus, filaments of cortex, after Börgesen. 100 × 1.
152. Derbesia marina, frond with sporangia, after Saunders. 40 × 1; zoospore, after Solier. 300 × 1.
153. Vaucheria Gardneri, after Gardner. 100 × 1.
154. Udotea cyathiformis, after Harvey. 1 × 1.
155. Bryopsis plumosa, after Kützing. 20 × 1.
156. Halimeda Opuntia, after Göbel. 1 × 1.
157. Phyllosiphon Arisari, surface view, after Kühn. 40 × 1.

PLATE XVIII.

158. Dichotomosiphon tuberosus, with oogonia and antheridia, after Ernst. 50 × 1.
159. Ostreobium Quekettii, after Bornet and Flahault. 250×1.
160. Caulerpa prolifera, after Reinke. 1 × 1.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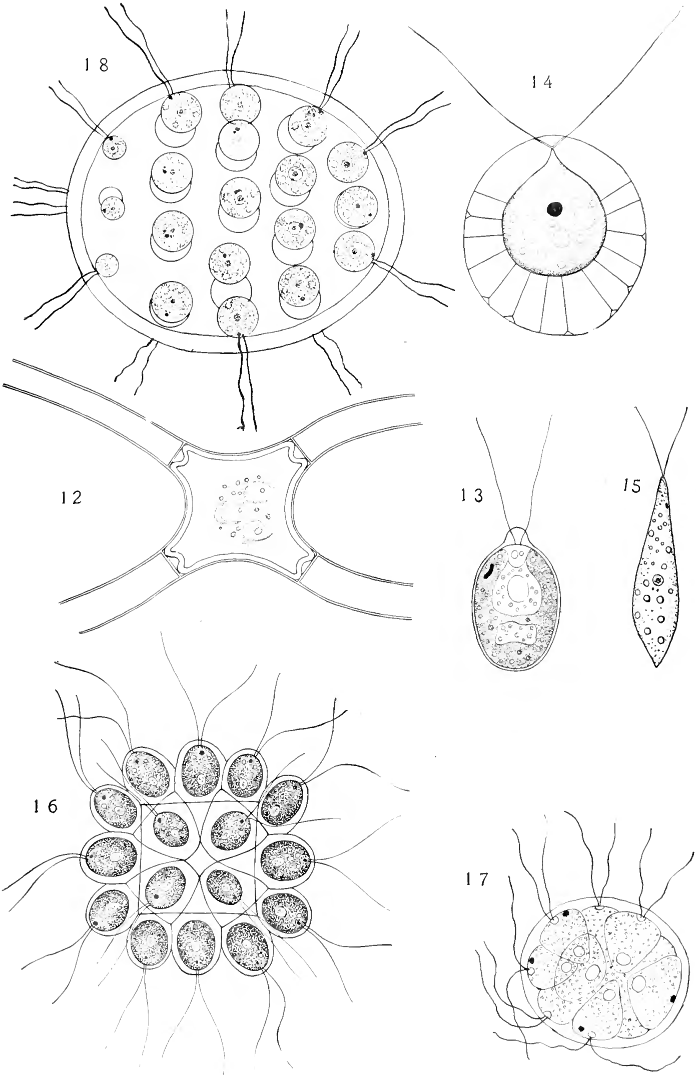
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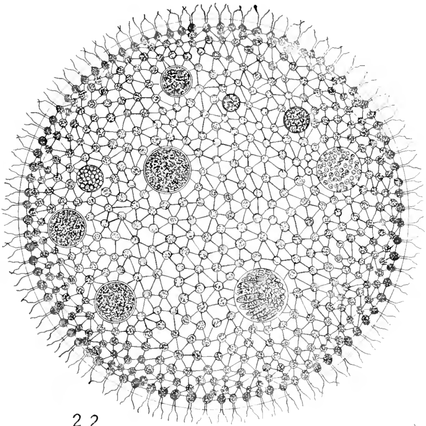

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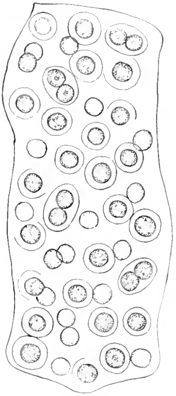

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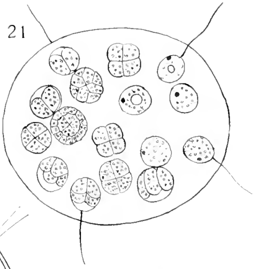

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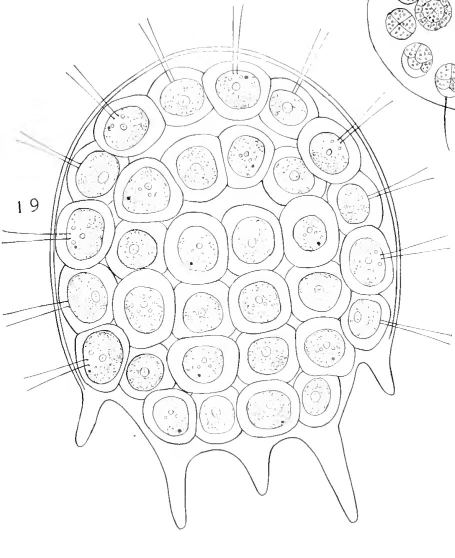

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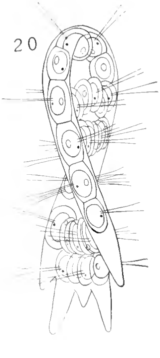

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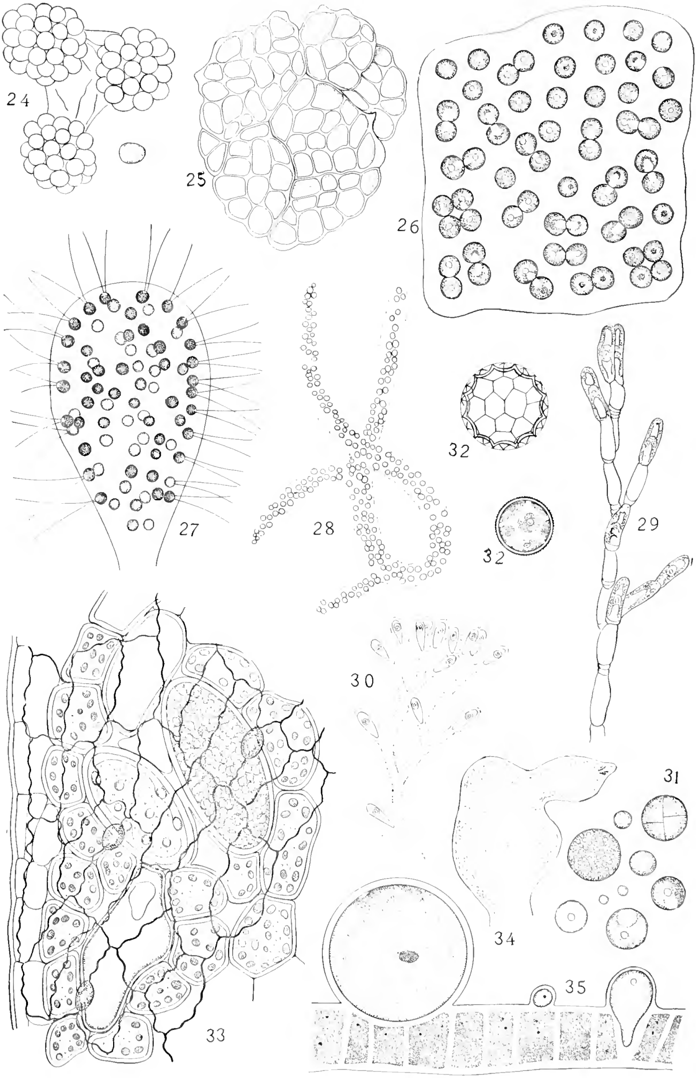
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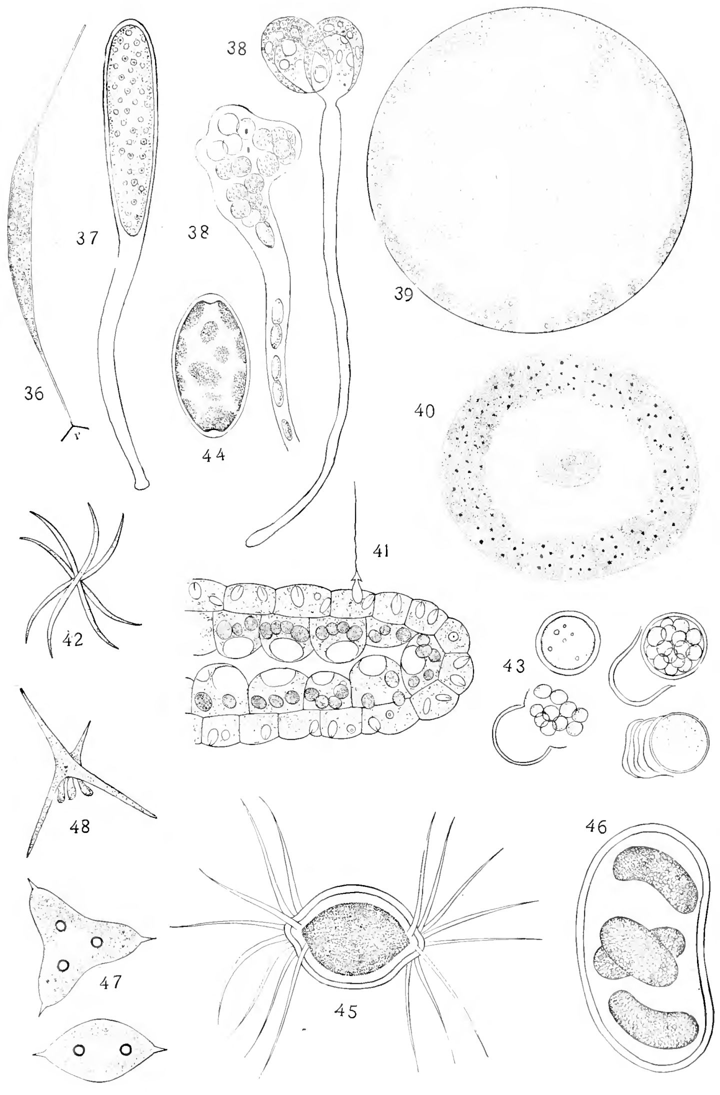
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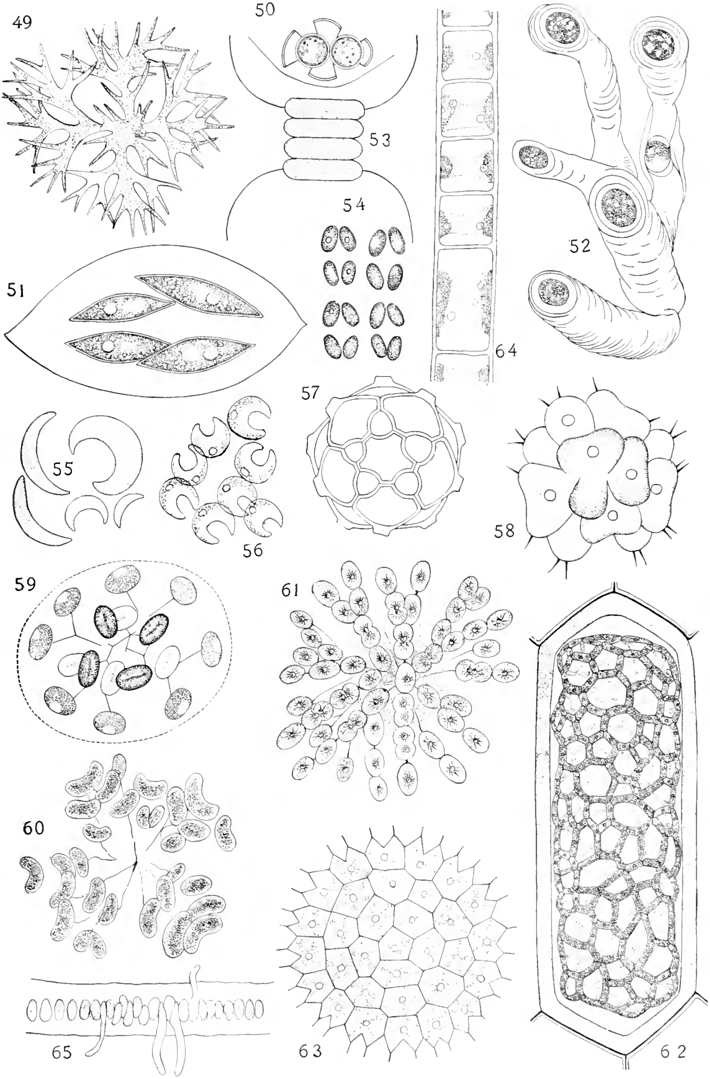
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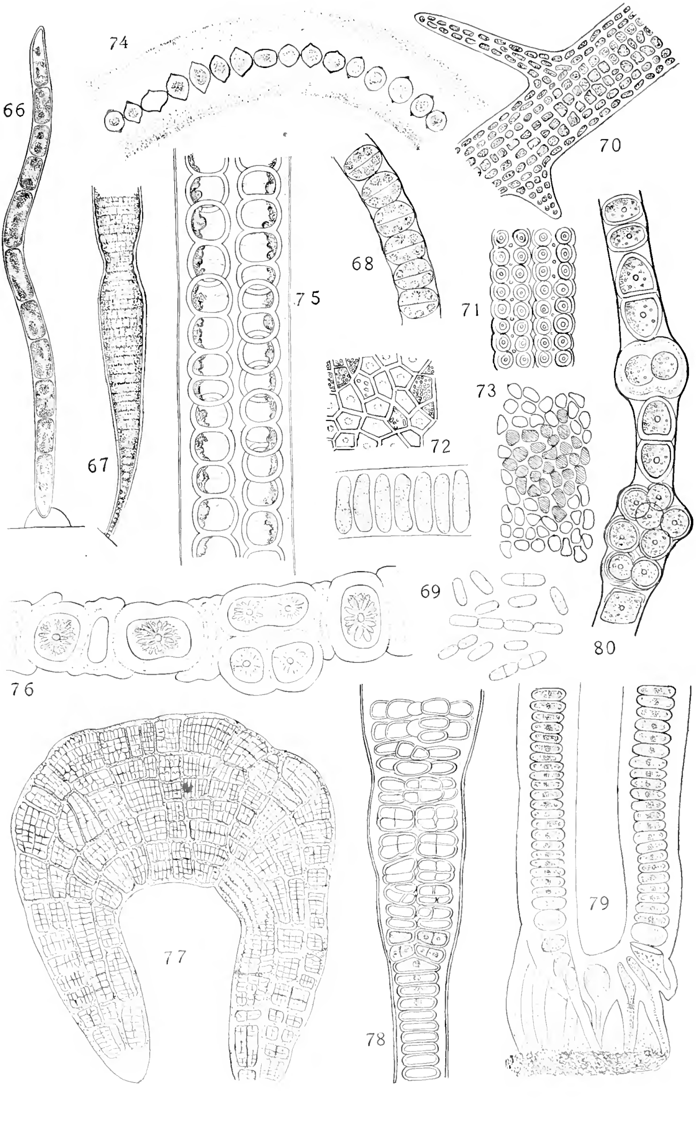
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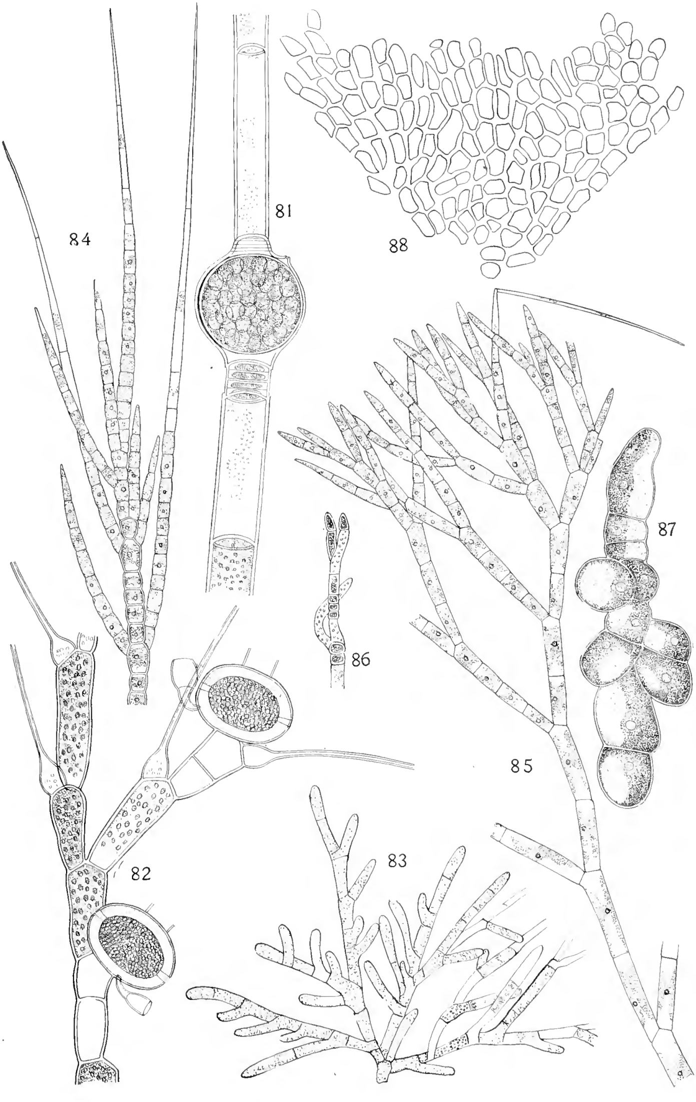
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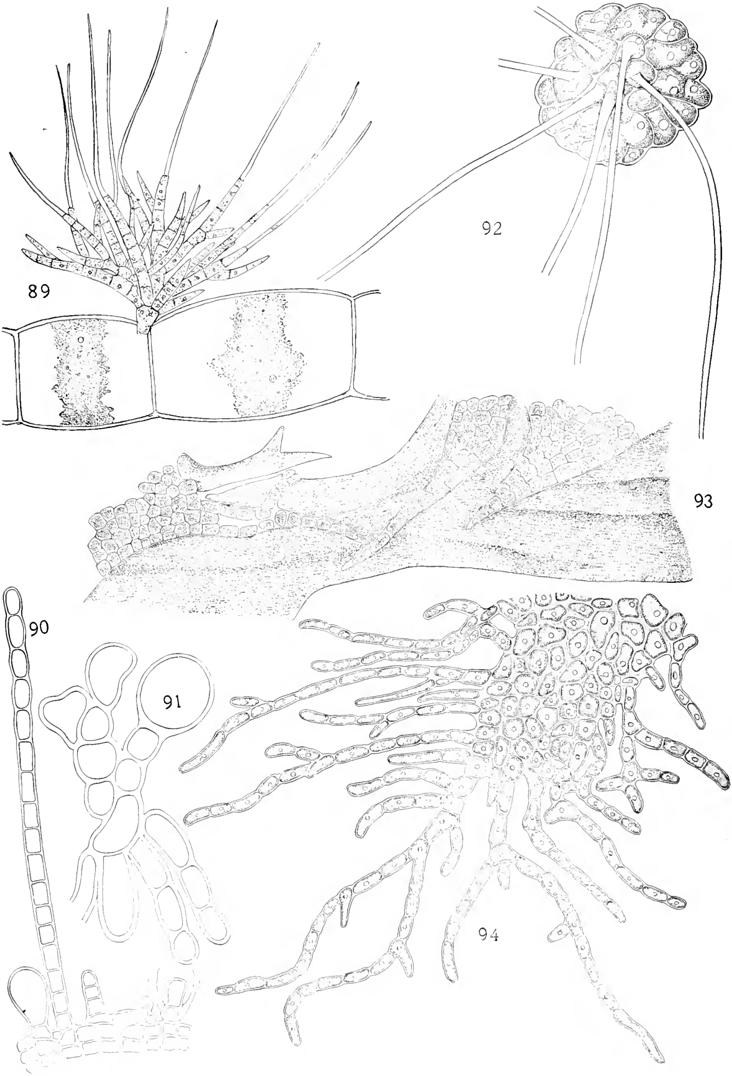
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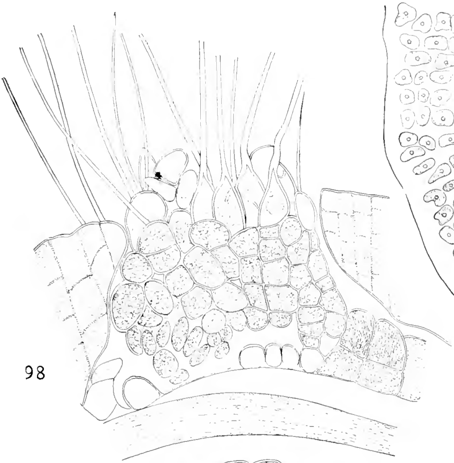

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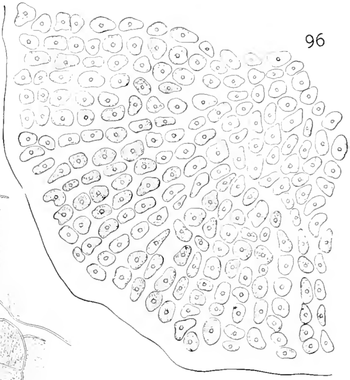

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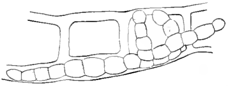

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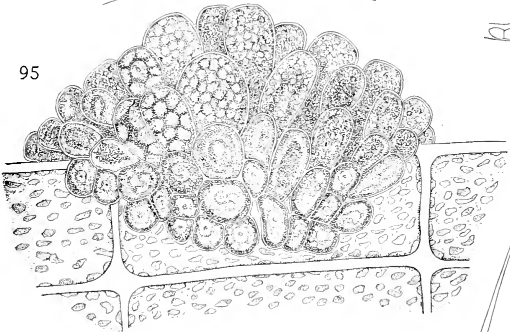

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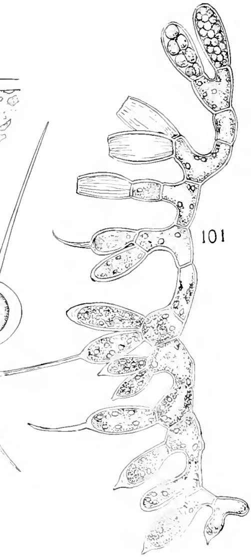

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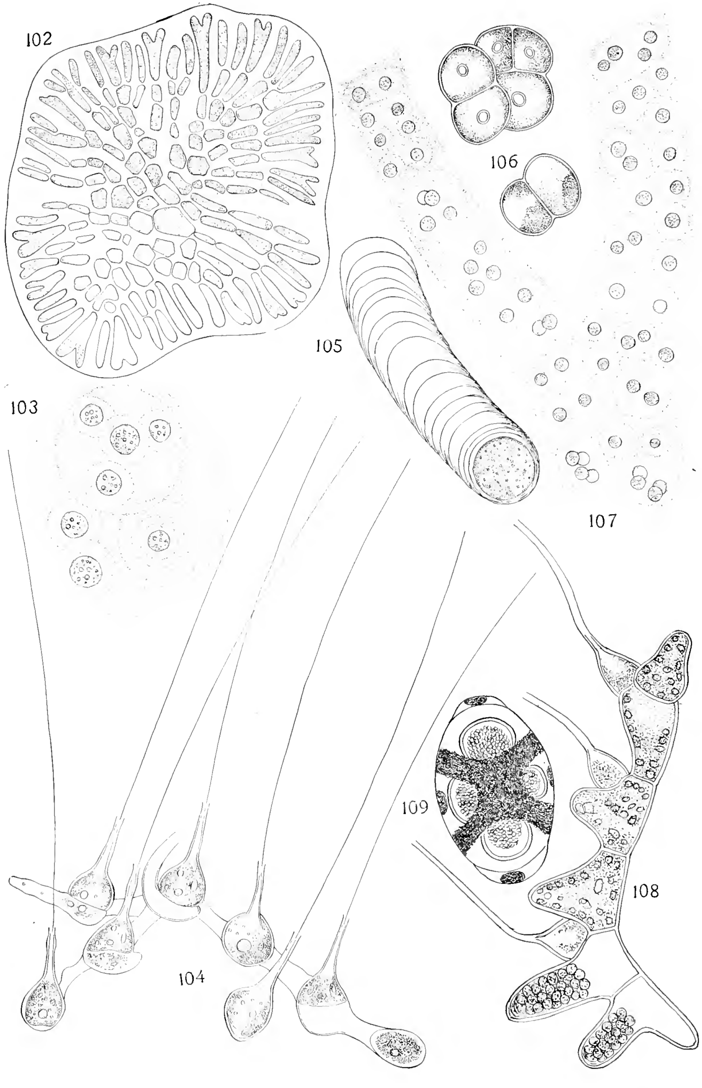
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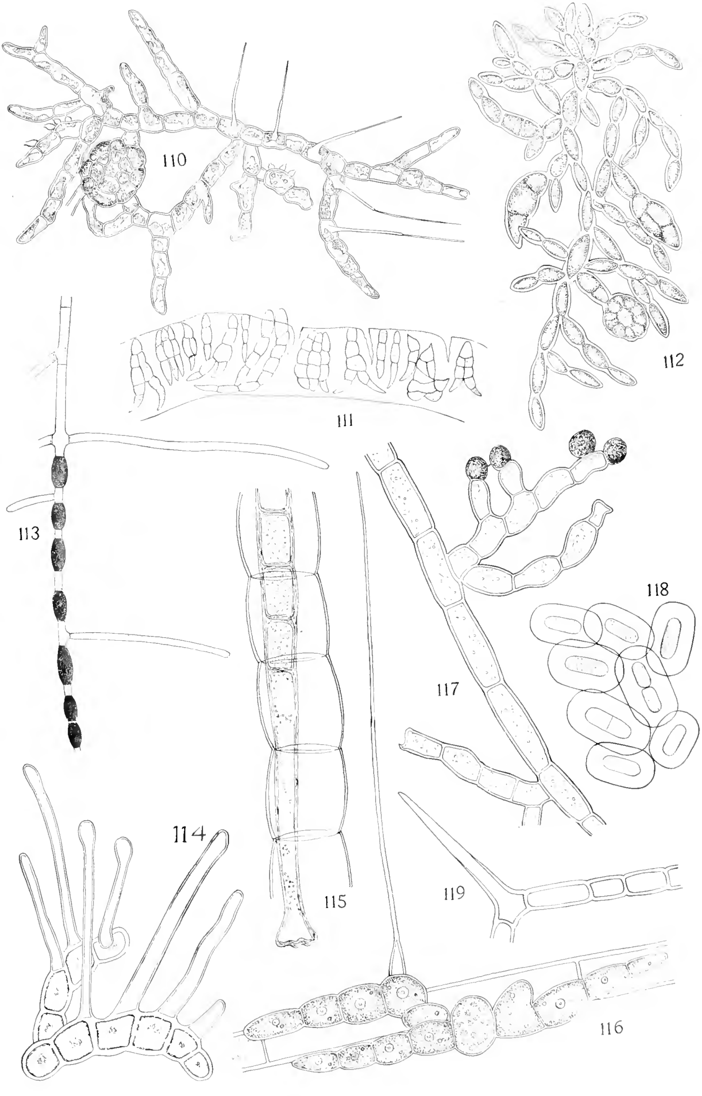
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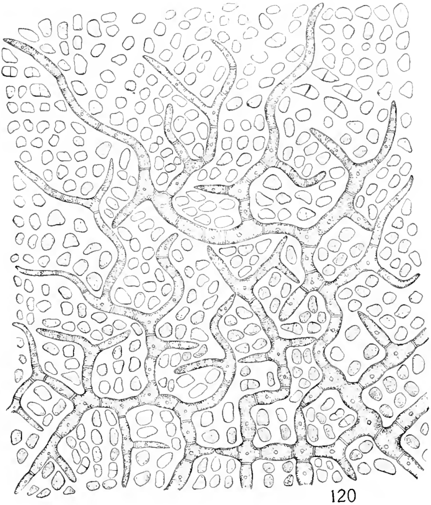

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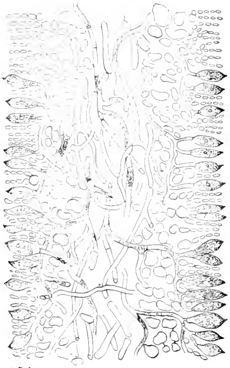

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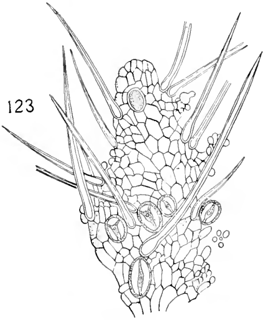

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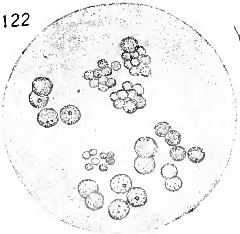

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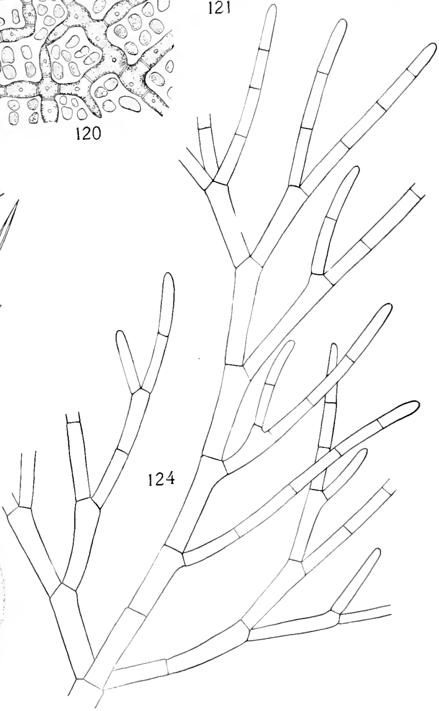

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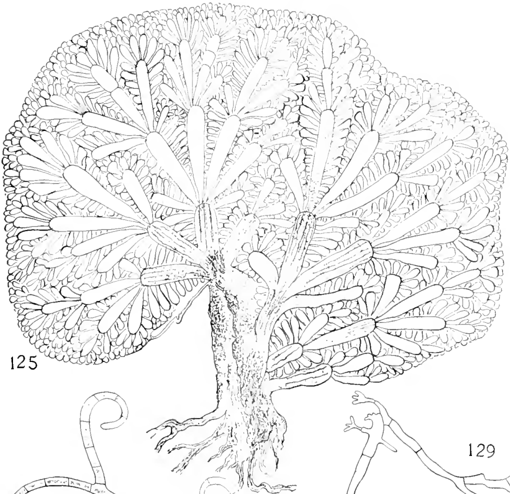

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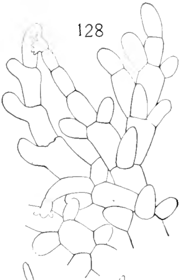

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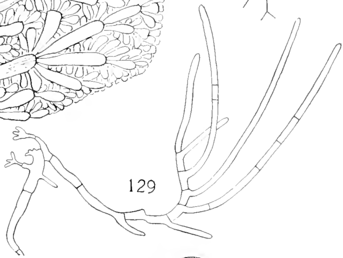

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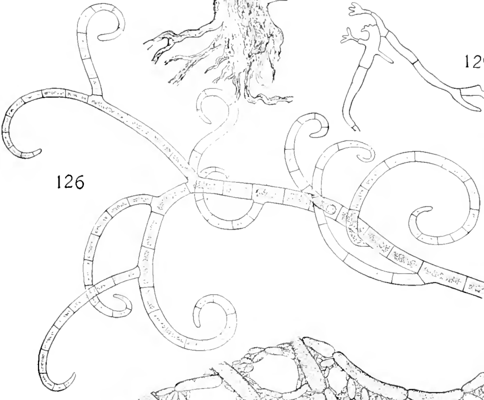

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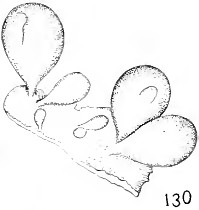

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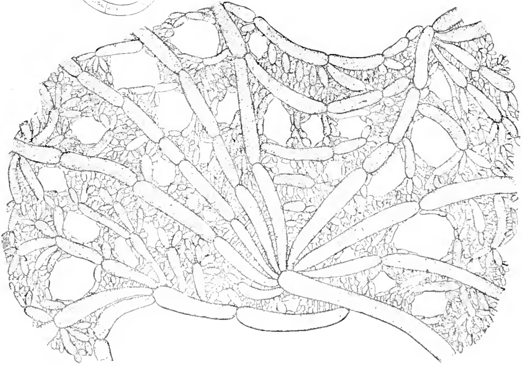

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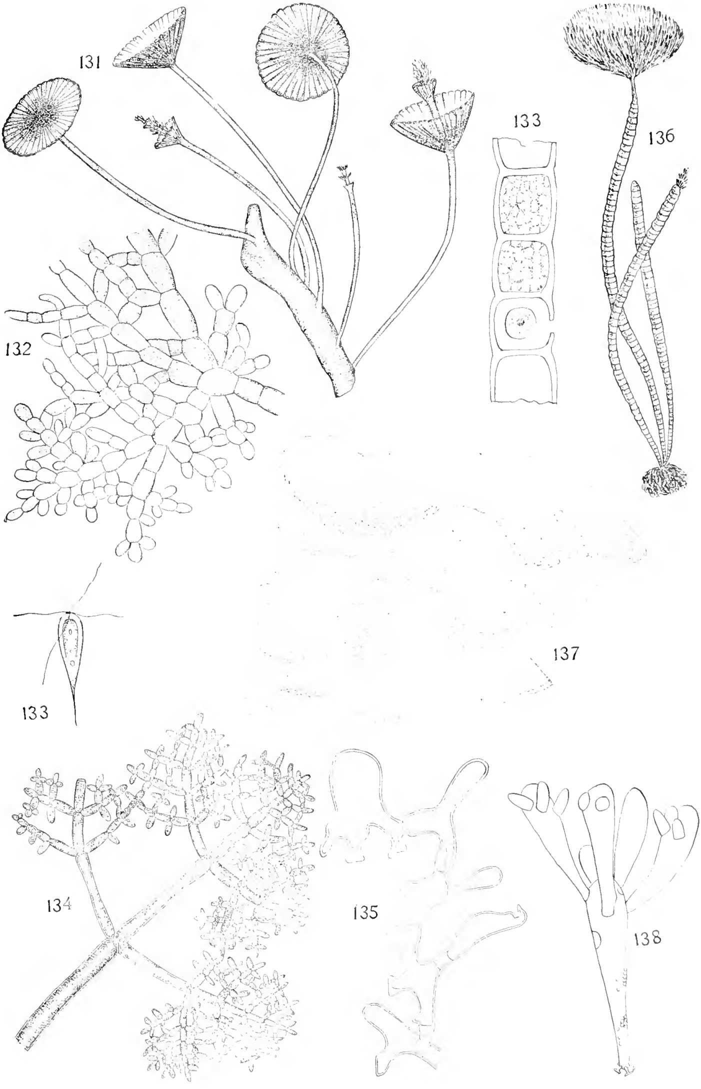
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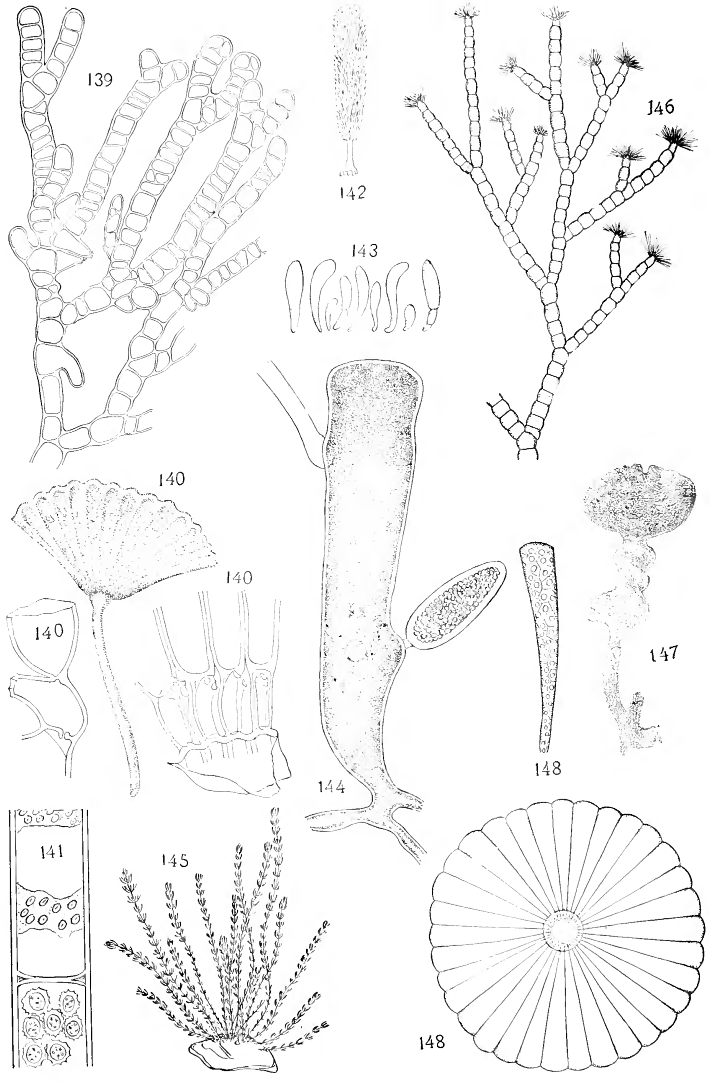
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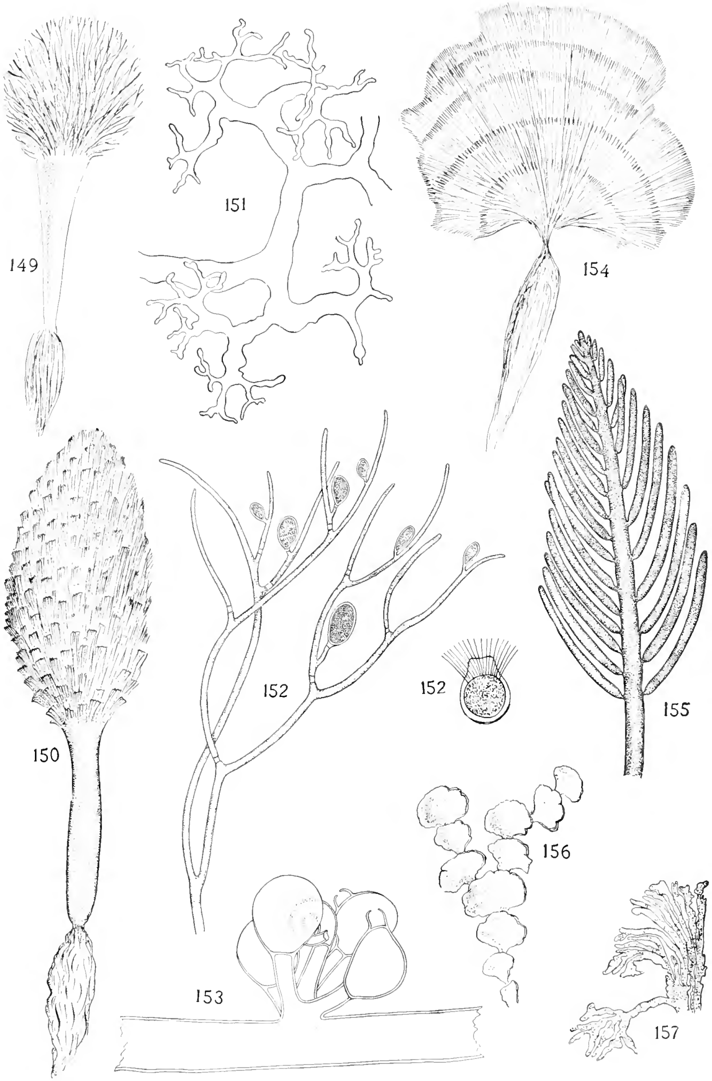
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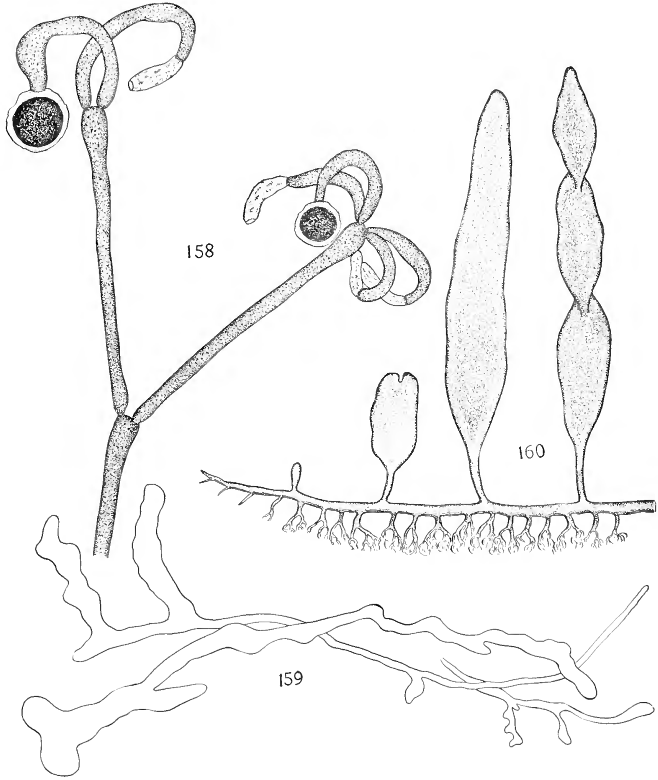
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